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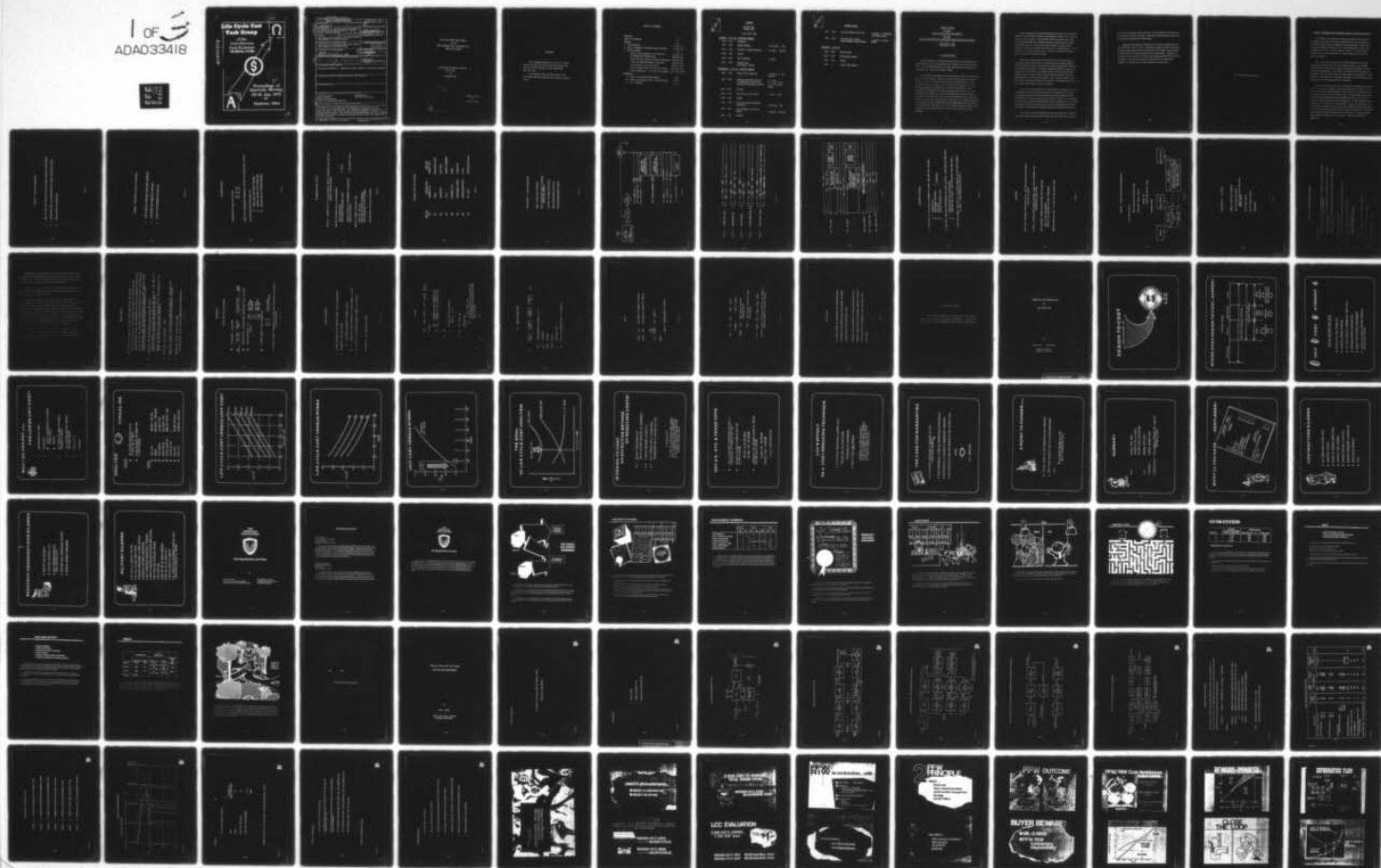
FAIRCHILD CAMERA AND INSTRUMENT CORP MOUNTAIN VIEW CA--ETC F/G 17/7
PROCEEDINGS OF THE LIFE CYCLE COST TASK GROUP OF THE JOINT SERV--ETC(U)
JUL 75 R B STAUFFER

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Life Cycle Cost Task Group

of the
Joint Services
Data Exchange
FOR INERTIAL SYSTEMS

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Proceedings of
Quarterly Meeting
29-31 July 1975
at
Fairborn, Ohio

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER 14 AGMC-76-086	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER 9	
4. TITLE (and Subtitle) 6 Proceedings of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems, Quarterly Meeting, 29-31 July 1975 at Fairborn, Ohio.		5. TYPE OF REPORT & PERIOD COVERED Final rept.	
7. AUTHOR(s) Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems		8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 12 195p.	
11. CONTROLLING OFFICE NAME AND ADDRESS AGMC/XRXE 407985 Newark Air Force Station, OH 43055		12. REPORT DATE 31 July 1975	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 10 Russell B. Stauffer		13. NUMBER OF PAGES 228	
15. SECURITY CLASS. (of this report) UNCLASSIFIED		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report) Distribution Statement A: Approved for Public Release; Distribution Unlimited			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)			
18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Life Cycle Costing Inertial Systems Failure Free Warranties Reliability Improvement Warranties Design-to-cost Life Cycle Cost Model			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) These proceedings describe the seventh quarterly meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems held 29-31 July 1975 in Fairborn, Ohio. The conference proceedings include the slides and texts of the invited papers which were available, the minutes of the Executive Board meeting, a list of terms and acronyms used in life cycle costing and reports of progress in special working groups and on the task groups life cycle cost model.			

LIFE CYCLE COST TASK GROUP
OF THE
JOINT SERVICES DATA EXCHANGE FOR
INERTIAL SYSTEMS

PROCEEDINGS OF QUARTERLY MEETING
29 JULY 1975
AT
FAIRBORN, OHIO

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2. AUTHOR	
3. PERIODICITY	
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Compiled and Edited
by
Russell B. Stauffer

ABSTRACT

These proceedings describe the activities of the seventh quarterly meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems held 29-31 July 1975.

The proceedings contain the slides and text of the invited papers which were available and the results of sub-group meetings.

TABLE OF CONTENTS

ABSTRACT	ii
TABLE OF CONTENTS	iii
AGENDA	iv-v
1. INTRODUCTION	1-1 thru 1-4
2. MODEL PROGRESS & WORKING GROUP ACCOMP.	2-1 thru 2-24
3. INVITED PAPERS	3-1
Design to Cost Implications to Life Cycle Cost	3-3 thru 3-22
The CONUS NAV VOR/ILS Radio	3-23 thru 3-38
Inertial Gyro Life Cycle Costs Analysis & Management	3-39 thru 3-54
Failure Free Warranties/Reliability Improvement	3-55 thru 3-94
Army Utilization of Life Cycle Costing	3-95 thru 3-132
F-16 Air Combat Fighter Life Cycle Cost Program	3-133 thru 3-150
Avionics Proliferation - A Life Cycle Cost Perspective	3-151 thru 3-178
APPENDICES	
A. Minutes of the Executive Board Meeting	A 1-4
B. Symbols and Definitions used in Life Cycle Costing	B 1-6
C. List of Attendees	C 1-6



AGENDA

HOLIDAY INN
Fairborn, Ohio

JULY 29-31, 1975

TUESDAY - JULY 29 - WORKING SESSION

8:30 - 9:15	Registration	
9:15 - 9:30	Opening Remarks	R. B. Stauffer - DRC
9:30 - 11:30	Discussion of Model Development	K. Gibson - Autonetics
11:30 - 1:00	LUNCH	
1:00 - 2:00	Task Assignments	K. Gibson
2:00 - 5:00	Working Groups (Continuing as required)	

WEDNESDAY - JULY 30 - INVITED PAPERS

9:00 - 9:45	Design to Cost Implications	F. Merlino & R. Adel Northrop
9:45 - 10:30	Reliability Improvement Warranty for CONUSNAV VOR/ILS Radio: Procurement Requirements and Prices	E. I. Feder U. S. Army (ECOM) Dr. R. A. Kowalski AIRINC
10:30 - 10:45	COFFEE	
10:45 - 11:30	Inertial Gyro Life Cycle Costs	P. Palmer - CSDL
11:30 - 1:00	LUNCH	
1:00 - 1:45	Failure Free Warranties/Reliability Improvement	O. Markowitz - ASO
1:45 - 2:30	Army Utilization of Life Cycle Costing	T. McGuire - NAVCON
2:30 - 2:45	COFFEE	



AGENDA (Cont'd)

2:45 -- 3:30	Life Cycle Costing on the F-16	P. Stewart -- AFSC/MMOA Joint Working Group
3:30 -- 4:30	Life Cycle Cost of Avionics: Inertial Navigation System Examples	R. Genet & T. Meitzler AGMC

THURSDAY -- JULY 31

9:00 -- 10:30	Working Groups
10:30 -- 11:30	Working Group Reports
11:30 -- 1:00	LUNCH
1:00 --	Executive Board Meeting

PROCEEDINGS
OF THE
LIFE CYCLE COST TASK GROUP
OF THE
JOINT SERVICES DATA EXCHANGE FOR INERTIAL SYSTEMS

JULY 29-31, 1975
FAIRBORN, OHIO

1. INTRODUCTION

The 1975 Summer meeting of the Life Cycle Cost Task Group of the JSDE/IS was held at the Holiday Inn, Fairborn, Ohio on July 29-31, 1975. The meeting convened on Tuesday Morning with a report by the chairman, Mr. Russell B. Stauffer (DRC).

Mr. Stauffer commented on the requirement to elect new members to the Executive Board. Since all members were elected last August for two-year terms and the charter calls for half the members to be elected each year, a request was made that one member from each of the groups (Industry, Government, Academic Research), resign; Mr. Stauffer resigned as the Academic Research member, Mr. Adel (Northrop) as the Industry member and although he was not present, it was agreed that since Mr. Laird (NAS North Island) had been appointed to fill a vacancy, he should stand for reelection. Mr. Stauffer appointed a nominating committee consisting of Don DeBurkarte of Collins Radio, Mr. Russell Genet of AGMC, Mr. Peter Palmer of Charles Stark Draper Laboratory and requested that they report at the Thursday business meeting.

At the Thursday meeting the nominating committee recommended that Mrs. Frieda Kurtz of ASD, be nominated to replace Mr. Laird and that Mr. James Taylor of Honeywell be elected to replace Mr. Adel. It was requested that Mr. Stauffer stand for reelection since besides Mr. Stauffer and Mr. Palmer there are no other members of the Academic Research community who attend on a continuing basis. There being no nominations from the floor, the three members cited above were elected to the Executive Board.

There was a discussion about plans for the next meeting of the Task Group and the decision was made that such a meeting should be held in conjunction with a meeting of the parent organization (JSDE/IS) in November in Florida. It was also suggested that there might be a requirement for an interim meeting in order that work on the model and the suggested User's Guide could be discussed and be ready for presentation at the November meeting. Since a call for papers at the November meeting had already been issued, it was requested that members submit their ideas as soon as possible.

Mr. Stauffer also briefed the membership on his April meeting in Washington with the LOMAC/REAC/ad hoc committee on Life Cycle Costing of the NSLA and on the results of the Seaview Meeting of the LOMAC/REAC Group at Absecon, New Jersey in June. He emphasized the fact that speakers representing high levels of government at the June meeting had made it very clear that Life Cycle Costing and warranty provisions will definitely be present in all new military procurements.

The balance of the meeting was divided into two parts. Section 2 of the proceedings discusses the progress on the model and the action

of the working groups which took place over the balance of Tuesday and on Thursday morning. Section 3 contains the invited papers which were presented during the day on Wednesday.

Appendix A contains the Minutes of the Executive Board meeting held Thursday, July 31, 1975. Appendix B contains a list of terms and acronyms applicable in the Life Cycle Cost areas which were provided by Pete Palmer of Charles Stark Draper Laboratories. Readers are invited to add to the list or to make any corrections which they feel are necessary. Commentary should be addressed to the Chairman. Appendix C contains a list of the attendees at the meeting.

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2. MODEL PROGRESS AND WORKING GROUP ACCOMPLISHMENTS

Keith Gibson of Autonetics opened the discussion of progress on the model with a discussion of some difficulties he had encountered in utilizing the input schemes suggested by Don DeBurkate. These problems are identified in Figures 1 and 2 and culminated in some recommendations which are shown in Figures 3 and 4. The final result of this discussion was a proposed new card indexing scheme which is shown in Figure 5.

Since there were many persons present who had not heard the previous discussion on the old card indexing scheme, Mr. Stauffer requested Don DeBurkate to describe his recommendations to provide a basis for comparison. (The reader is referred to the February proceedings of the LCC Task Group for information on that scheme.) Since there were obviously some unresolved questions, the problem was then left to one of the working groups for resolution.

Keith Gibson then turned to the discussion of programming in general. He began by showing the tasks accomplished (see Figure 6) and discussing the flow charts (Figures 7 and 8 and in 9). He indicated that the basic algorithms had been coded except for the RDT&E section; that the override techniques had been developed and that in the course of doing so he had identified some discrepancies. He also suggested some changes in the procedures that he wanted to follow, discussed the override technique (Figure 10) and raised some additional questions (Figures 11 and 12). Remaining activities are as shown in Figure 13. The discussion culminated with the identification of the series of working groups which might be required for the session. These are identified in Figure 14.

PROBLEM -- ITEM DATA COMPLEXITY

- ONE LRU /SRU MAY HAVE DATA ON 6 OR MORE DIFFERENT INPUT SHEETS
- ACQUISITION AND O & M SEPARATION HAS CAUSED REDUNDANT INPUTS
- INPUT DETAIL TOO EXHAUSTIVE

Figure 1

PROBLEM - OPERATIONAL ACTIVITY DEFINITION

- **INPUTS NOW ON 8 DIFFERENT CARDS AND REDUNDANT**
- **DEPLOYMENT NOT COMPLETELY SPECIFIED**
- **ACTIVITY RELATIONSHIPS NOT SPECIFIED**

Figure 2

RECOMMENDATIONS

COMBINATION OF SOME DATA CARDS :

201 and 202
214 and 215

MAKE FIELD ENGINEERING MANMONTHS VARIABLE PER OPERATIONAL ACTIVITY

USE IDENTIFICATION DATA CARD TO :

- A) INPUT DATA FOR REPORT HEADING
- B) IDENTIFY REPORTS TO BE GENERATED
- C) REPLACE END OF ITERATION SENTINEL

Figure 3

RECOMMENDATIONS (CONT'D)

MOVE ALL "COMMON DATA" TO THE 000 SERIES, IDENTIFY STANDARD DATA AND HAVE
DEFAULT VALUES IN MODEL

ADD THE FOLLOWING NEW O & M CATEGORIES:

SUPPLY MANAGEMENT	}	TOTAL
MAINTENANCE MANAGEMENT DATA		
SUPPORT EQUIPMENT MAINTENANCE & CALIBRATION	}	BY ACTIVITY LEVEL
RECURRING TRAINING		

DEVELOP A SINGLE CARD INPUT FOR:

EACH LRU / SRU, ETC.
EACH ITEM OF SUPPORT EQUIPMENT
EACH MAINTENANCE ACTIVITY TYPE(S?)

RENUMBERING OF CARDS AS DISCUSSED

Figure 4

PROPOSED NEW CARD INDEXING

<u>CARD NO.</u>	<u>EXISTING TYPE</u>		<u>NEW TYPE</u>	
	COMMON DATA		COMMON DATA	
000				
100	RDT&E		DEPLOYMENT DATA	
200	ACQUISITION		UNIT DATA	
300	O & M		SUPPORT EQUIPMENT	
400	OVERRIDE DATA		RDT&E	
500	DEPLOYMENT CONCEPT		ACQUISITION	
600	IDENTIFICATION DATA		O & M	
700	NOT USED		IDENTIFICATION DATA	

Figure 5

PROGRAMMING - TASKS ACCOMPLISHED

MODEL FLOW CHART PREPARED

BASIC ALGORITHMS CODED (FORTRAN)
(RDT&E NOT WORKED)

OVERRIDE TECHNIQUE DEVELOPED

SOME DISCREPANCIES IDENTIFIED

CHANGES/IMPROVEMENTS NOTED

Figure 6

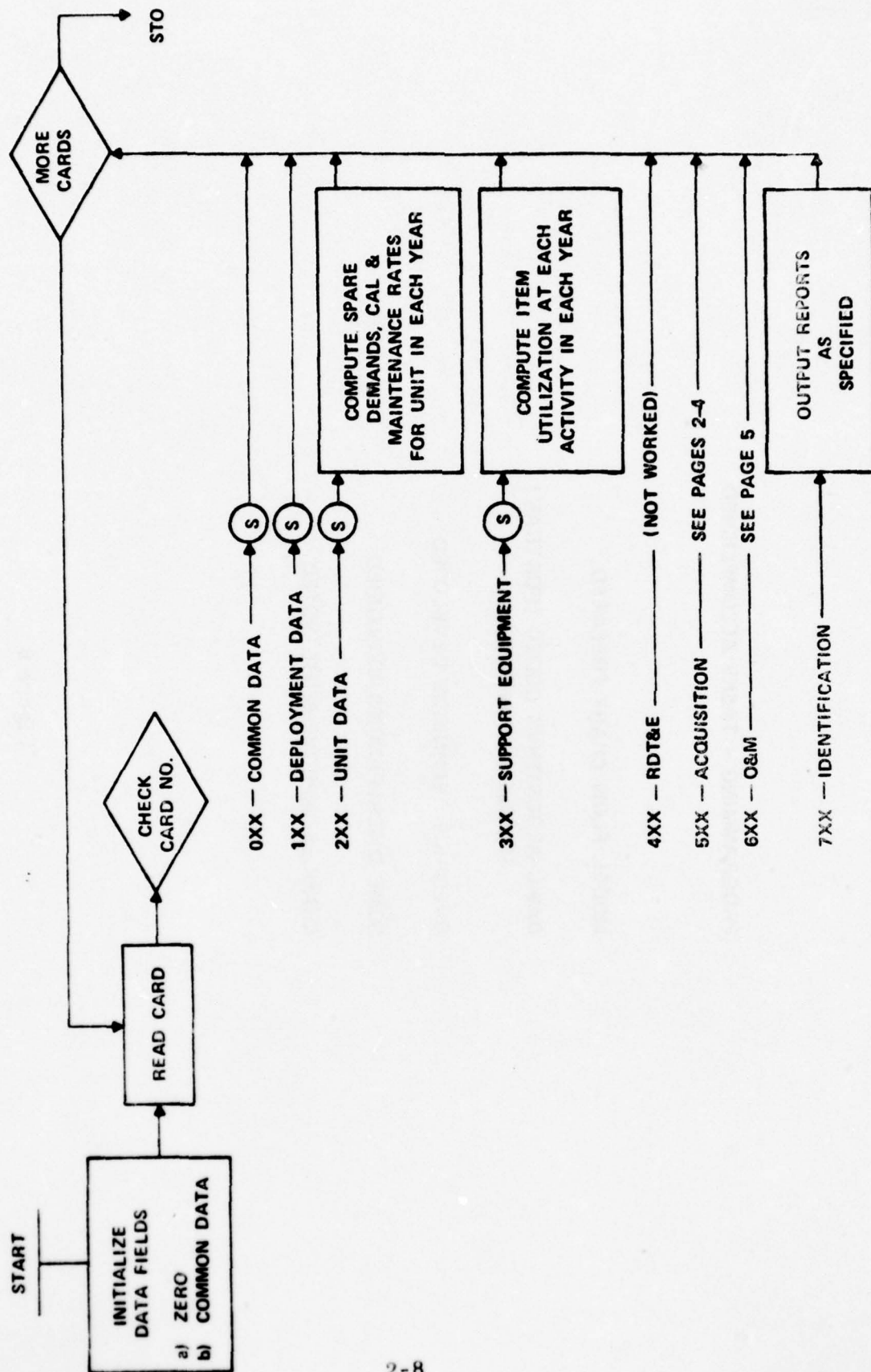


Figure 7

- 5 X 1 - PRODUCTION T&TE

$$\left[\begin{array}{l} X > 0 \text{ --- TTEA} = \text{INPUT} \text{ ---} \\ X = \textcircled{S} \text{ --- TTEA} = \text{TTEA} + \text{CTE (J)} * \text{QTE (J)} \text{ ---} \end{array} \right.$$

- 5 X 3 - RECURRING ACQ.

$$\left[\begin{array}{l} X > 0 \text{ --- SRAC} = \text{INPUT} \text{ ---} \\ X = 0 \text{ --- } \textcircled{S} \text{ --- SRAC} = \text{NS} * \text{UC}_q \text{ ---} \end{array} \right.$$

- 5 X 4' - INSTALLATION

$$\left[\begin{array}{l} X > 0 \text{ --- CINST} = \text{INPUT} \text{ ---} \\ X = 0 \text{ --- } \textcircled{S} \text{ --- CINST} = \text{---} \end{array} \right.$$

- 5 X 5 - PRODUCTION START-UP

$$\left[\begin{array}{l} X > 0 \text{ --- CSU} = \text{INPUT} \text{ ---} \\ X = 0 \text{ --- } \textcircled{S} \text{ --- CSU} = \text{CSU} + \text{CSUA (J)} \text{ ---} \end{array} \right.$$

- 5 X 8 - INITIAL SUPT. EQUIP.

$$\left[\begin{array}{l} X = 9 \text{ --- TSEA} = \text{INPUT} \text{ ---} \\ X = 8 \text{ --- } \textcircled{S} \text{ --- SEA 1-5, SEAMOD 1-5, SEPAR 1-5} = \text{INPUT COMPUTE TSEA} \\ X = 0 \text{ --- } \textcircled{S} \text{ --- COMPUTE TSEA} \text{ ---} \end{array} \right.$$

Figure 8

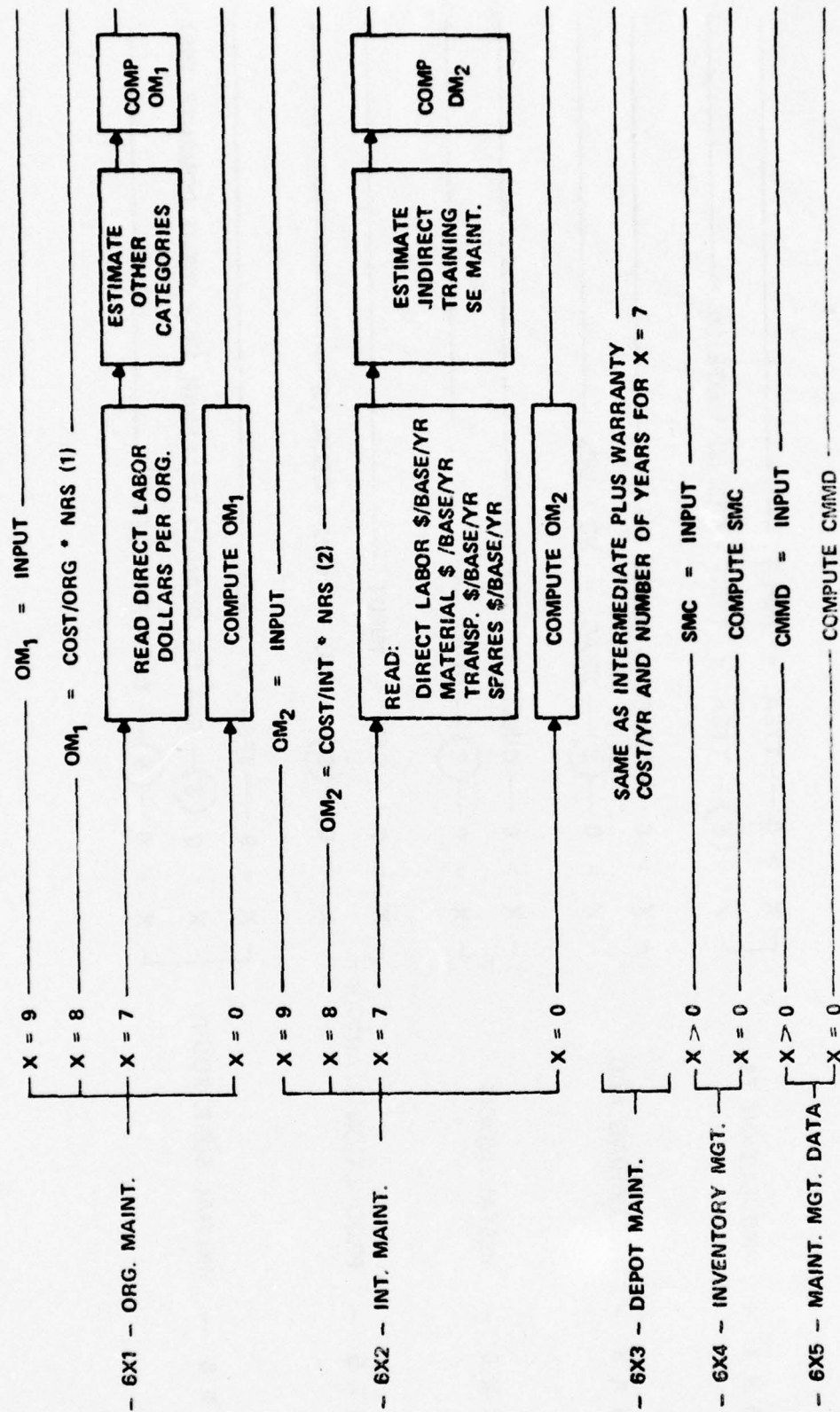


Figure 9

VERRIDE TECHNIQUE

A. FIRST INPUT ALL DATA WHICH IS COMMON TO MORE THAN ONE COST CATEGORY

- | | | |
|----|------------------------|---------------|
| 1) | COMMON DATA |) AS NEEDED (|
| 2) | DEPLOYMENT DEFINITION | |
| 3) | UNIT DATA | |
| 4) | SUPPORT EQUIPMENT DATA | |

B. THEN INPUT ONE CARD REPRESENTING EACH COST CATEGORY. CARD WOULD EITHER HAVE:

- 1) DETAILED DATA FOR CALCULATIONS
- 2) OVERRIDE DATA VALUES (MAY HAVE MORE THAN ONE LEVEL)

IF NO CARD IS INPUT, THE VALUE OF THE COST CATEGORY ON THE OUTPUT REPORT IS "NCTS" (NOT CONSIDERED THIS STUDY)

Figure 10

QUESTIONS

HOW ABOUT COMBINING PRODUCTION T & T E AND PRODUCTION STARTUP COSTS
INTO ONE CATEGORY

IS THERE A CORRELATION BETWEEN STUDENT LABOR RATE (TRAINING) AND
MAINTENANCE LABOR RATE?

TEST EQUIPMENT LOADING INCLUDES TIME FOR CALIBRATION

WHAT IS THIS CALIBRATION?
SHOULD IT BE INCLUDED IN DIRECT MANPOWER?

TRAINING MATERIAL COST -- A TOTAL OR PER COURSE BASIS?

Figure 11

PROBLEM - SPARES INVENTORY REQUIREMENTS

NEED DEFINITION OF

WHAT ITEMS ARE STOCKED WHERE

INVENTORY SUPPLY PERIOD

REPAIR TAT

ORDER AND SHIPPING TIMES

DEMAND RATES

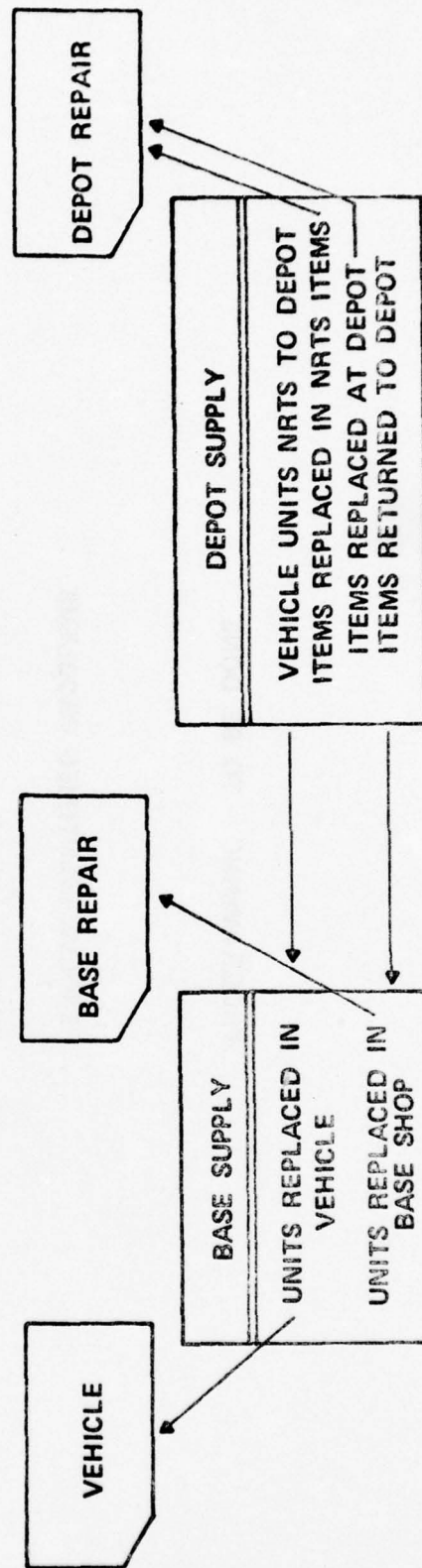


Figure 12

PROGRAMMING - TO BE DONE

RESOLVE IDENTIFIED PROBLEMS

FINISH ALGORITHM CODING

IMPACT OF PROBLEM RESOLUTION
RDT&E MODEL

INPUT CARD CODING

OUTPUT REPORT CODING

DEBUGGING

Figure 13

POSSIBLE WORKING GROUPS THIS SESSION

I. COMMON DATA*

IDENTIFY ALL DATA INPUTS WHICH ARE NOT A FUNCTION OF SPECIFIC STUDIES,
HARDWARE, OR MAINTENANCE CONCEPTS

DEVELOP PLAN FOR OBTAINING STANDARD VALUES FOR INPUT TO THE MODEL
AS DEFAULT VALUES

PREPARE A MEANS FOR IDENTIFYING ALTERNATIVE VALUES AND UPDATING
STANDARD VALUES

II. SPARES INVENTORY DEFINITION

DEFINE INVENTORIES, DEMAND RATES AND INVENTORY PERIOD

III. INPUT CARD CONSOLIDATION AND SIMPLIFICATION

UNIT DATA
DEPLOYMENT DEFINITION
SUPPORT EQUIPMENT DEFINITION

IV. ROT&E MODEL

DO WE WANT TO DO ANYTHING MORE WITH IT?

V. ALPHABETICAL LIST OF VARIABLE NAMES

VI. PARENT BODY PRESENTATIONS*

Figure 14

Working Group 1 consisting of Jim Taylor and Chuck Eddy agreed to work on the identification of common data. Because of other commitments they were unable to complete their work during the course of the meeting. Their response will be forthcoming shortly.

Tasks 2 and 3 were combined in a group consisting of Bob Adel, Frank Merlino, Don DeBarkarte and Dwight Collins and resulted in the responses shown in Figure 15 and 16.

Task 4 on the RDT&E Model was assigned to Pete Palmer, Tom Maguire, Freida Kurtz and Earl Feder all of whom (with the exception of Mr. Feder) had participated in the original development. The basic recommendation in this group was that in spite of the shortcomings, the algorithms should be coded into the model since the override technique would permit them to be ignored as required. The group also reviewed the equations as they were written and made recommendations for certain changes. These are shown in Figures 17-21. They also defined some future goals in the RDT area which is shown in Figure 22.

Brian Klatt of Northrop took on the responsibility for alphabetizing the terms used in the model. This work was completed and turned over to Keith Gibson and will appear as part of the User's Guide. It is not included in these proceedings.

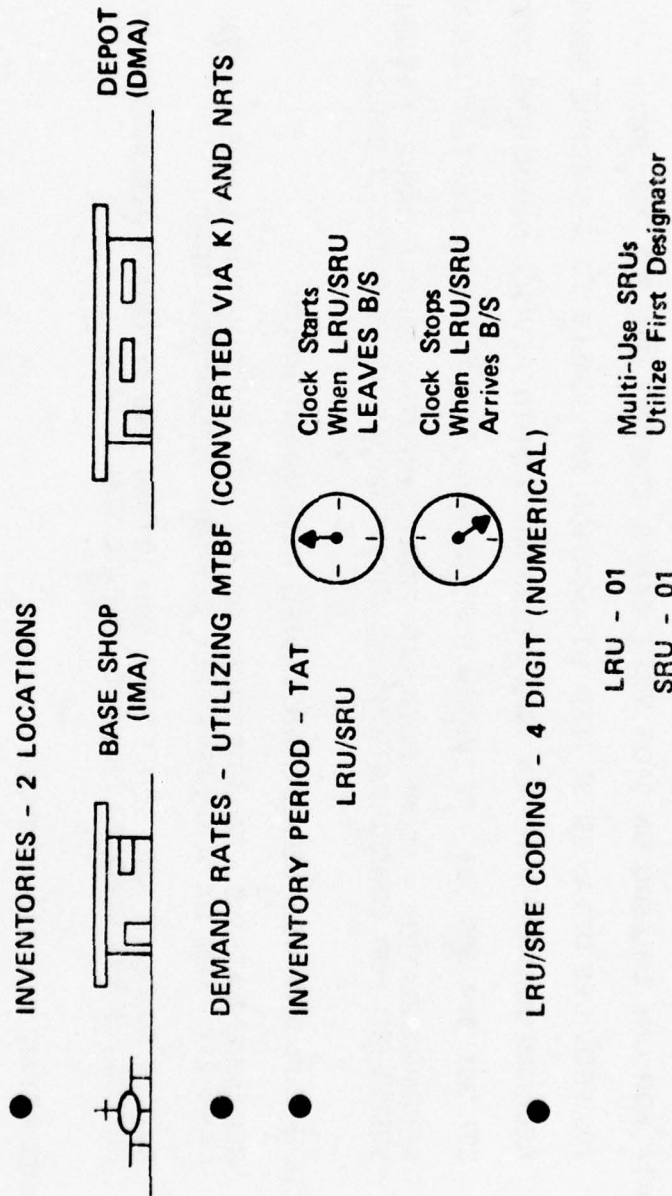
PROBLEM AREAS

- A. DATA FOR ONE LRU/SRU ON 6 OR MORE CARDS, (206, 207, 301, 302, 202, 304) :
206 PROVIDES DETAILED SE ITEM UTILIZATION APPLICABLE TO A SPECIFIC SRU/LRU
RECOMMENDATION - RETAIN AND INCORPORATE INTO REVISED NUMBERING SYSTEM AS 3XX
207, 301, 302, 303, 304 - PREVIOUSLY SEPARATED TO FACILITATE PARTIAL LCC COMPUTATION
RECOMMENDATION - SCOPE DOES NOT PERMIT INPUT AS SINGLE CARD. REVISED FORMATS
SUBMITTED FOR CONSIDERATION AND INCLUSION AS REVISED 2XX, 3 CARDS.
- B. ACQUISITION AND O&M SEPARATION CAUSED REDUNDANT INPUTS
RECOMMENDATIONS - DELETE TNOS (200); NS (203); NI (204); NRS 3, NRS 1 (307); AND ALL OF
CARD 211. SUM DATA ON PROPERLY DEFINED DEPLOYMENT CARD.
REVIEW SOH (200) AND SOH 1 THRU SOH 10 (306) AND IF TRULY REDUNDANT DELETE THE
EXCESS. 306 IS USED TO PROVIDE ANNUAL SUB-TOTALS.
- C. INPUT DETAIL TOO EXHAUSTIVE. TRUE!
- D. OPERATIONAL ACTIVITY DEFINITION ON 8 CARDS AND REDUNDANT. DEPLOYMENT NOT
COMPLETELY SPECIFIED. ACTIVITY RELATIONSHIPS NOT COMPLETELY SPECIFIED.
- E. COMBINE SOME (200-201, 214-215) DATA CARDS
RECOMMENDATION: REVISED FORMATS SUBMITTED FOR CONSIDERATION.

Figure 15

ASSIGNMENT 2

SPARES INPUTTING DEFINITIONS



D. COLLINS - SPECIAL ASSIGNMENT TO INVESTIGATE MOD METRIC APPLICABILITY TO LCC MODELING

Figure 16

GENERAL COMMENTS

1. RDT&E EQUATIONS SHOULD REMAIN IN MODEL AND BE PROGRAMMED *
2. RECOMMEND THAT USER EITHER :
 - A) USE MAJOR ELEMENTS AS OVERRIDE VALVES
 - OR B) MAKE HIS OWN BEST ESTIMATES OF PROPORTIONALITY VALUES
3. IF (A), REFER TO EQUATIONS PROVIDED IN MODEL FOR GUIDANCE

* AS MODIFIED - SEE APPROPRIATE FIGURE

Figure 17

RDT&E

$$1. \quad \text{TSER} = \text{DPCZ} + \left[(\text{NTV}) (\text{LTP}) (\text{TVOP}) \right] \left[\text{COH} \right]$$

CORRECT : --

NTH = NUMBER OF TEST HARDWARE SETS

TO : NTV = NUMBER OF TEST HARDWARE SETS

2. TSS

FACTOR SF TO BE DETERMINED

MAY BE \geq 1.0
 $<$

3. CS = EH + SAH + CST

RATHER THAN :

$$\text{CS} = \text{TI} (\text{EH} + \text{SAH} + \text{CST})$$

TI = TECHNOLOGY INDEX TO BE ELIMINATED
BUT CONSIDERED IN DETERMINING OTHER
THREE FACTORS.

Figure 18

D E (DESIGN ENGINEERING)

$$D E = \left(\frac{PROP 1}{ACC} \right) \left(\frac{PROP 2}{MTBF} \right) \left(\frac{PROP 3}{MTTR} \right) \left(\frac{PROP 4}{AT} \right) DEP$$

PROP = PROPORTIONALITY FACTOR 1, 2, 3, 4

ACC = ACCURACY

MTBF = FAILURE

MTTR = REPAIR

AT = ALIGNMENT TIME

DEP = ED COST OF KNOWN SYSTEM (\$ ADJUSTED)

Figure 19

R D T E

R P M C A D D : P E R M O N T H X N U M B E R O F M O N T H S

P R M G A D D : P E R M O N T H X N U M B E R O F M O N T H S

$$T S R = \left(\frac{\overline{TSRP}}{PCP} \right) DPC \quad (PROP 8)$$

WHERE :

PROP 8 = PROPORTIONALITY FACTOR

Figure 20

$$TNER = (NTI) (DPC) + (NTL) (DPCA)$$

$$(CHANGE) + (TVOC) (TVOPT)$$

WHERE : TVOC = TEST VEHICLE COST PER
OPERATING HOUR

TVOPT = TEST VEHICLE OPERATING HOURS
FOR TRAINING

$$TNP = (MCM) (LTP) + (GTNH + TNCH) (MHG)$$

PRODUCT (TVOC) (TVOPT) WAS DELETED AND ADDED TO
MAINTAIN CONSISTENT EQUATION SUBJECTS.

Figure 21

FUTURE GOAL

THE RDT&E COMMITTEE RECOGNIZES THAT MUCH WORK WILL BE NEEDED IN DEVELOPING VALID CERS BEFORE THE RDT&E ALGORITHMS CAN BE CONSIDERED VALID.

HOWEVER, THE DEVELOPMENT OF RDT&E PROCEDURES IS AN URGENTLY-NEEDED COST REQUIREMENT AND WILL CONTINUE TO BE A MATTER OF CONCERN BY THE LIFE CYCLE COST TASK GROUP.

Figure 22

3. INVITED PAPERS

This section contains the viewgraphs used by the speakers and, in many cases, texts of their presentations. Each paper is preceded by a sheet identifying the author and their affiliations.

**DESIGN TO COST IMPLICATIONS
TO
LIFE CYCLE COST**

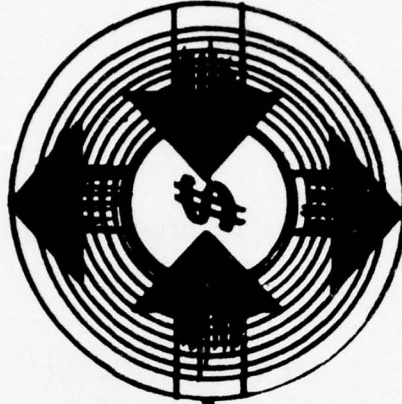
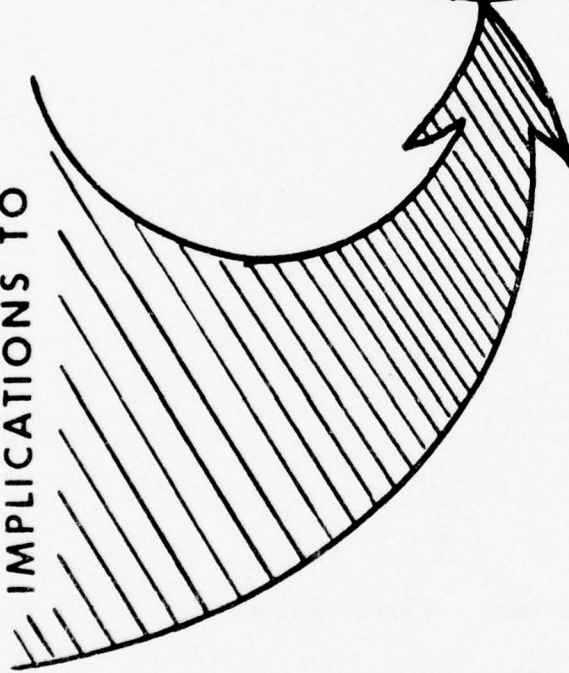
by

Robert Adel Frank Merlino

**Northrop Electronics
Hawthorne, California**

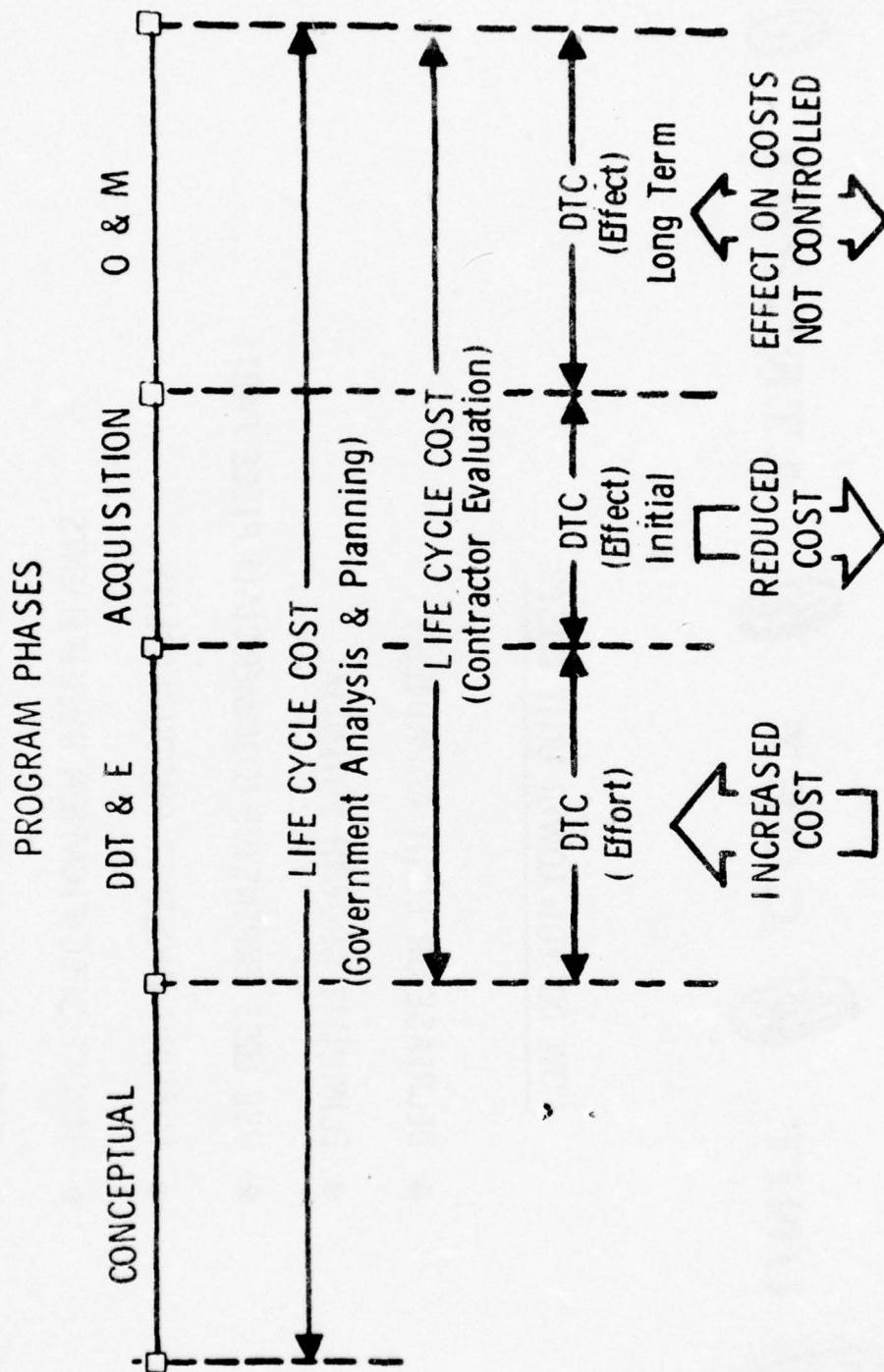
DESIGN TO COST

IMPLICATIONS TO



LCC

WHERE DOES DESIGN TO COST, HAPPEN?





UNIT



COST



ATROPHY



HOW DO YOU LOWER UNIT COST?

- DECREASE OR LIMIT CAPABILITY
- ELIMINATE GROWTH POTENTIAL
- USE LESS EXPENSIVE (COMMERCIAL) PIECE PARTS
- IMPROVE/INCREASE PRODUCABILITY
- REDUCE SPECIFICATION REQUIREMENTS
- LESSEN PIECE PARTS REQUIRED THROUGH DESIGN MODIFICATION

WHAT DO YOU PAY



FOR LOWER UNIT COST?

1. MAINTAINABILITY (MTTR)
2. RELIABILITY
 - SPARES (COMPENSATED BY REDUCED SPARES COSTS)
 - REPAIRS
3. RTS (REQUIRING MORE LRU's/WRA'S RETURNED TO DEPOT)
4. AGE (DICTATES NEED FOR SMARTER MACHINES/PEOPLE)
5. DATA (T.O.'s)
6. TRAINING

ANALYSIS



TYPICAL INS

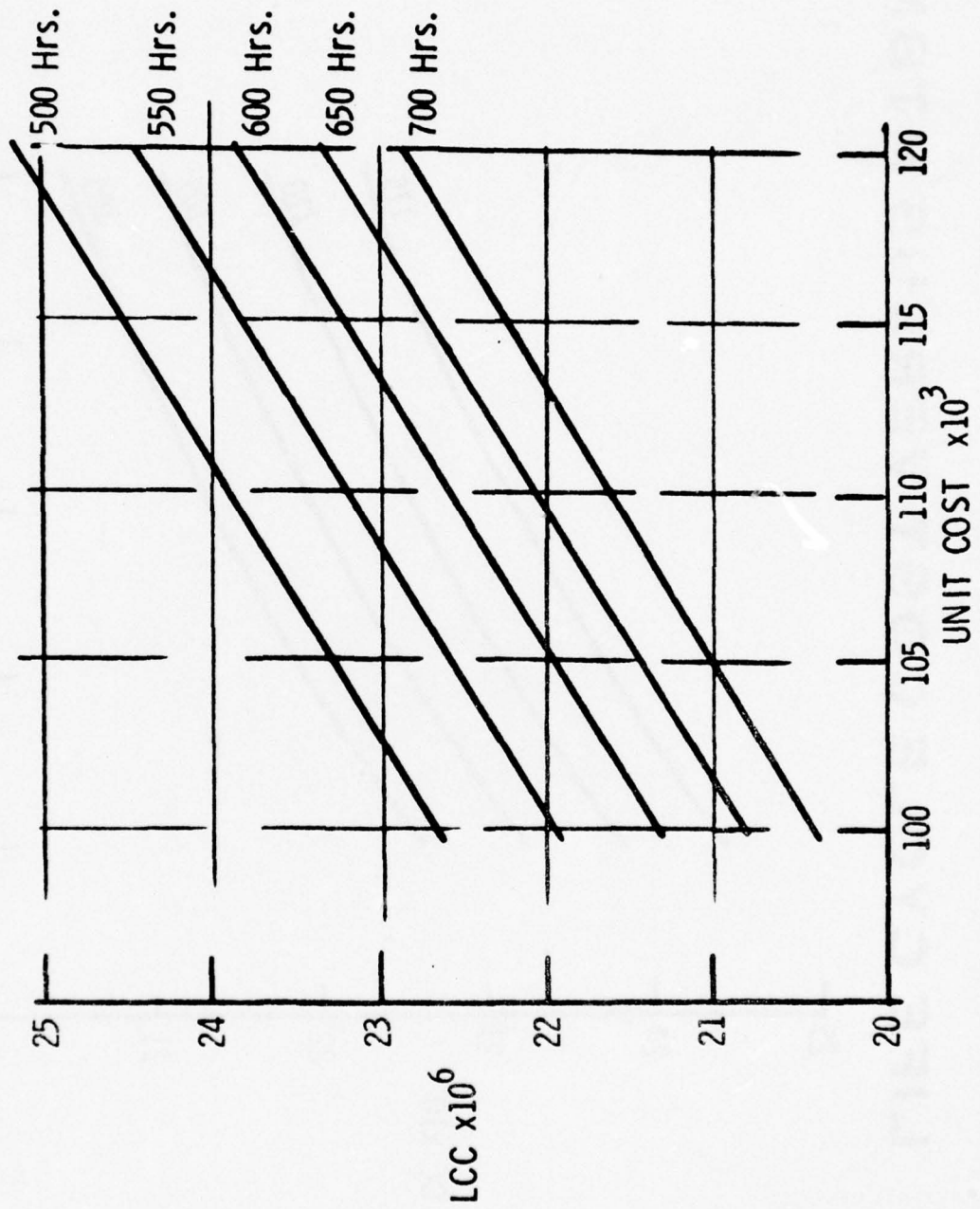
PROGRAM

- 100 AIRCRAFT OPERATING OUT OF 10 BASES FOR 10 YEARS
- FLYING 80 HOURS PER MONTH PER SYSTEM (AVERAGE)

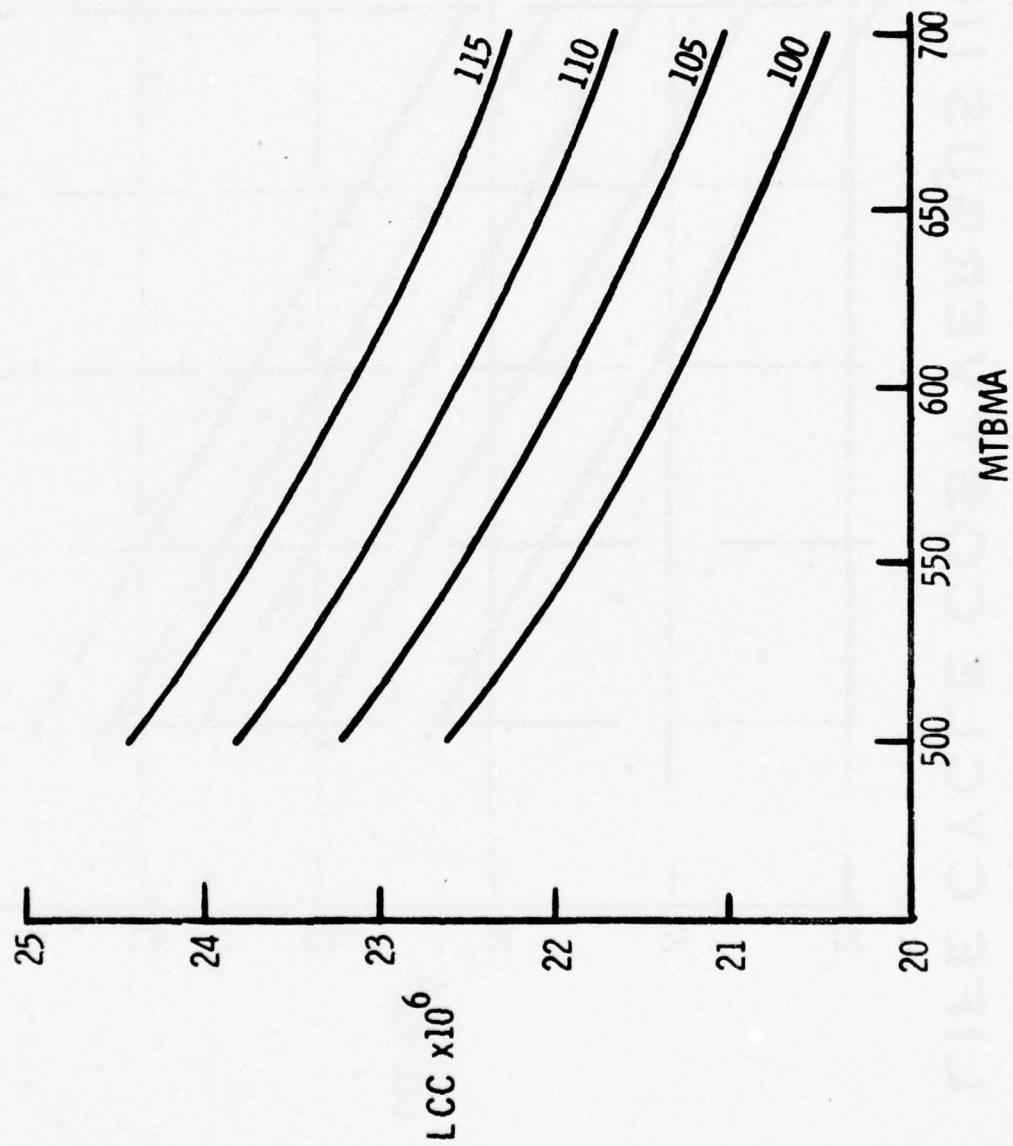
SYSTEM

- UNIT COST = \$100,000 - \$115,000
- MTBMA = 500 HOURS - 700 HOURS
- BASE REPAIR = 8 HOURS (IMU)
- DEPOT REPAIR = 120 HOURS (IMU)
- REPAIR MATERIAL = \$2000 PER REPAIR (IMU)
- FLIGHTLINE AGE = 0
- BASE AGE = \$75,000 PER BASE
- DEPOT AGE = \$1,000,000 (ONE DEPOT)

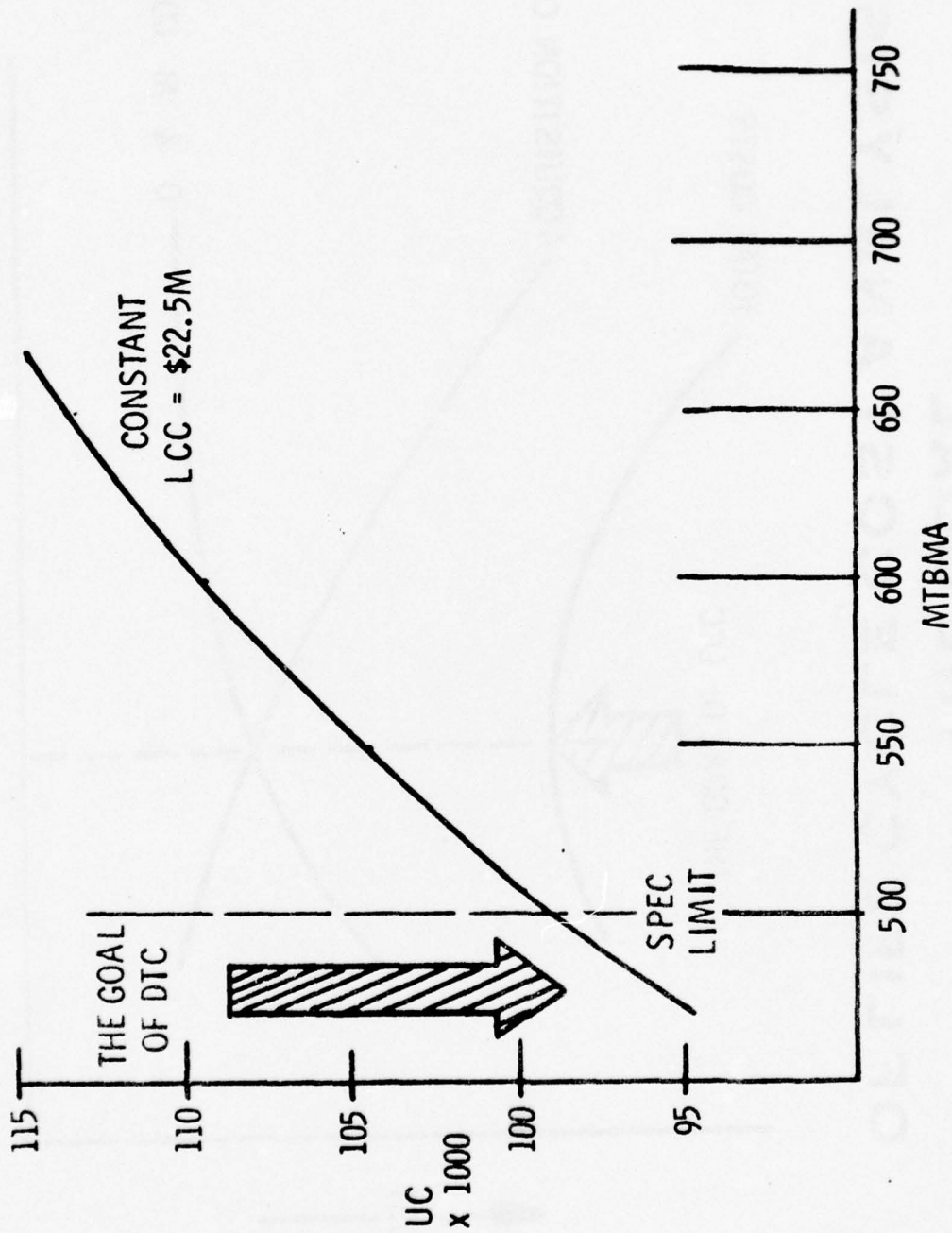
LIFE CYCLE COST VERSUS UNIT COST



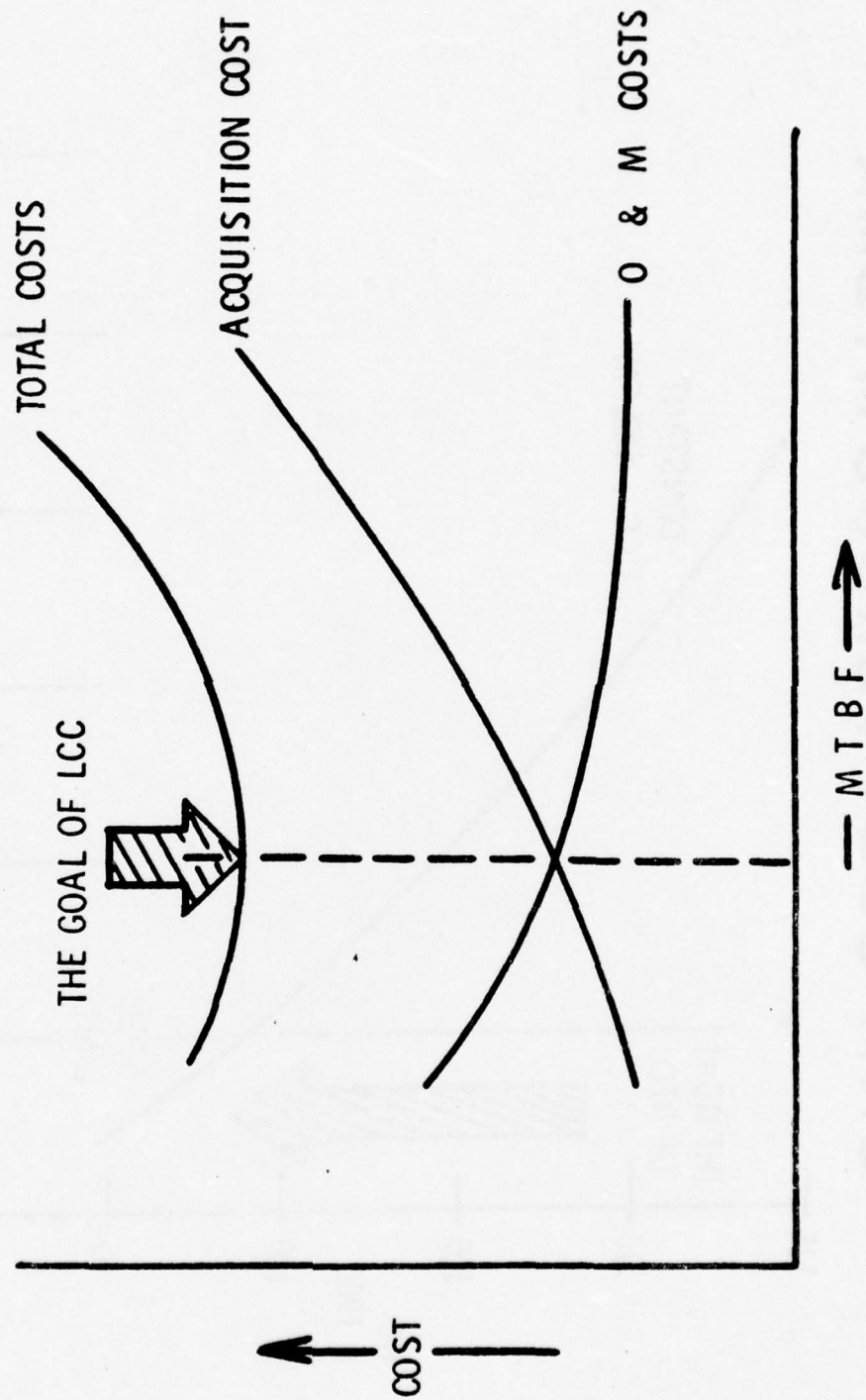
LIFE CYCLE COST VERSUS MTBMA



UNIT COST VERSUS MTBMA



THE GOAL OF LIFE CYCLE COST ANALYSIS



IS DESIGN TO COST AN EFFECTIVE METHOD OF REDUCING COSTS?

- IT REDUCES * ACQUISITION COST
 - * ONE OF THE MOST SENSITIVE LCC PARAMETERS
- IT IS EASILY MEASURED IN TODAY'S \$
- IT CAN * INCREASE DDT & E EXPENDITURES
 - * COMPENSATED FOR BY REDUCED UNIT COST

- H O W E V E R -

LCC MAY BE SACRIFICED SINCE DURING
DDT & E, CHANGES CAN BE INTRODUCED
WHICH REDUCE ACQUISITION COST BUT
INCREASE SUPPORT COSTS

DDT & E - DTC \$ TRADE OFFS

- HOW IS ADDITIONAL EXPENDITURE FOR DDT & E COUNTERACTED BY REDUCED UNIT COST?

- ASSUME A CURRENT ESTIMATED COST FOR AN INS IS \$75,000

500 SETS TO BE PROCURED

$$\$75,000 \times 500 = \$37,500,000$$

- INTRODUCE A DTC PROGRAM TASKED TO PROVIDE THE SAME INS AT \$70,000

$$70,000 \times 500 = \$35,000,000$$

$$\text{SAVINGS YIELD} = \$2,500,000$$

* IF LCC IS NOT SACRIFICED

LCC'S EFFECT AS A COST REDUCING TECHNIQUE

- IT OPTIMIZES ACQUISITION & SUPPORT COSTS
- SAVINGS MAY BE IN THE FUTURE
 - MINIMIZED BY DISCOUNTING
- DDT & E COSTS CAN INCREASE

ULTIMATELY LCC MAY BE REDUCED
IF DDT & E CHANGES WHICH INCREASE
ACQUISITION COSTS CAN BE OFFSET
BY REDUCED SUPPORT COSTS



THE CASE FOR WARRANTIES

- IF A WARRANTY PROVISION IS INCLUDED IN A DTC ACQUISITION CONTRACT →
- FIELD PERFORMANCE IS NOW THE CONTRACTORS RESPONSIBILITY
- MAINTAINABILITY & RELIABILITY BECOME VERY IMPORTANT
- LOW ACQUISITION COSTS ARE COUPLED TO LOW SUPPORT COSTS

RESULT



LCC REDUCTION



A POINT TO PONDER....

- WE HAVE DESIGN TO UNIT PRODUCTION COST PROGRAMS
- WHAT ABOUT DESIGN TO UNIT O & M CONSIDERATIONS?

WITH.

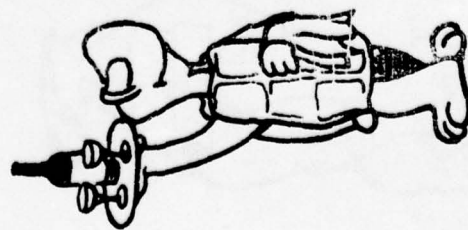
➤ THE TARGET DEFINED AS A PER
CENT OF PRODUCTION COSTS



SUMMARY

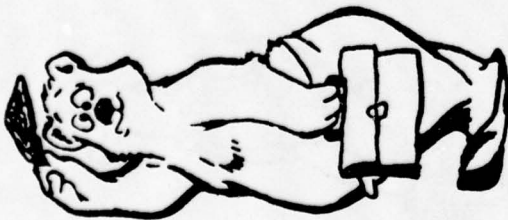
- DTC
 - REDUCES UNIT COST
 - INCREASES DDT & E COSTS
 - SUPPORT COSTS NOT DEFINED
- LCC
 - REDUCES TOTAL COST
- WARRANTY
 - REDUCES SUPPORT COST
- COMBINATIONS
 - WITH CAREFUL PLANNING MAY PROVIDE
THE BEST OF EACH

WHAT'LL YOU HAVE,.....GENTLEMEN?



PROGRAM	MENU
ENTREES	
DTC	\$-----
LCC	\$-----
WARRANTY	\$-----
DTC & LCC	\$-----
DTC & WARRANTY	\$-----
DTC, LCC & WARRANTY	\$-----
DESSERTS	
TOTAL PKG. PROCUREMENT	\$-----
AFSCM - 375	\$-----
C SPEC	\$-----

CONTRACTORS DILEMMA



- ALL CONTRACTOR'S DO NOT AGREE
- MARKETING GIMMICK
- REDUCE OR INCREASE COMPETITION?
- PROPOSAL COSTS INCREASE
- CONTRACT PRICING IS DIFFICULT
- PROGRAM MANAGEMENT COMPLEXITIES
- COMPLICATED CONTRACTS
- RISK!

RESEARCH ORGANIZATIONS DILEMMA



- MORE OR LESS BUSINESS?
- YOUR COST INCREASES LCCI
- DATA GATHERING/REPORTING
(WHO'S THE BAD GUY?)
- RELATIONS WITH CONTRACTOR'S/MILITARY
- COMPLEX CONTRACT MANAGEMENT



MILITARY DILEMMA

- RFP MUST BE CAREFULLY WRITTEN
- RFP WILL BE MORE COMPLICATED
- PROGRAM MANAGEMENT IS MORE DIFFICULT
- CONTRACTS ARE MORE COMPLICATED
- MUST UNDERSTAND CONTRACTOR'S PROBLEMS
- SOURCE SELECTION/JUSTIFICATION MORE PAINFUL
- MAY TAKE TIME TO REALIZE SAVINGS
- SPO ATTRITION
- WHAT DO YOU DO ABOUT OVERRUNS
- WHAT DO YOU DO ABOUT ECP'S
- POSSIBLE AREAS OF CONFLICT
- ALL INTERACTING GOVERNMENT AGENCIES MUST UNDERSTAND METHODS OF CONTROL

**THE
CONUS NAV
VOR/ILS RADIO**



RIW Requirements and Prices

by

**Mr. Earl I. Feder
U.S. Army Electronics Command
CONUS NAV VOR/ILS Project Manager**

**Dr. Richard A. Kowalski
ARINC Research Corporation
Annapolis, Maryland**

BIOGRAPHICAL SKETCHES

Mr. Earl I. Feder
U.S. Army Electronics Command
Avionics Laboratory
Fort Monmouth, New Jersey 07703

Mr. Feder received a BEE from Pratt Institute in 1950 and an MSEE from Rutgers in 1959. He is the Project Manager for the Army CONUS NAV VOR/ILS Program. In addition, he has had the technical responsibility for a number of airborne navigation systems, including the AN/ARN-103 TACAN and AN/APN-171A Radar Altimeter. The CONUS NAV Project Office is located in the Navigation Technical Area of the Avionics Laboratory, which has the overall prime objective of establishing and maintaining a system and technology base to support the development of airborne and ground avionics systems and the equipment required for Army air/airmobility operations.

Dr. Richard A. Kowalski
ARINC Research Corporation
2551 Riva Road
Annapolis, Maryland 21401

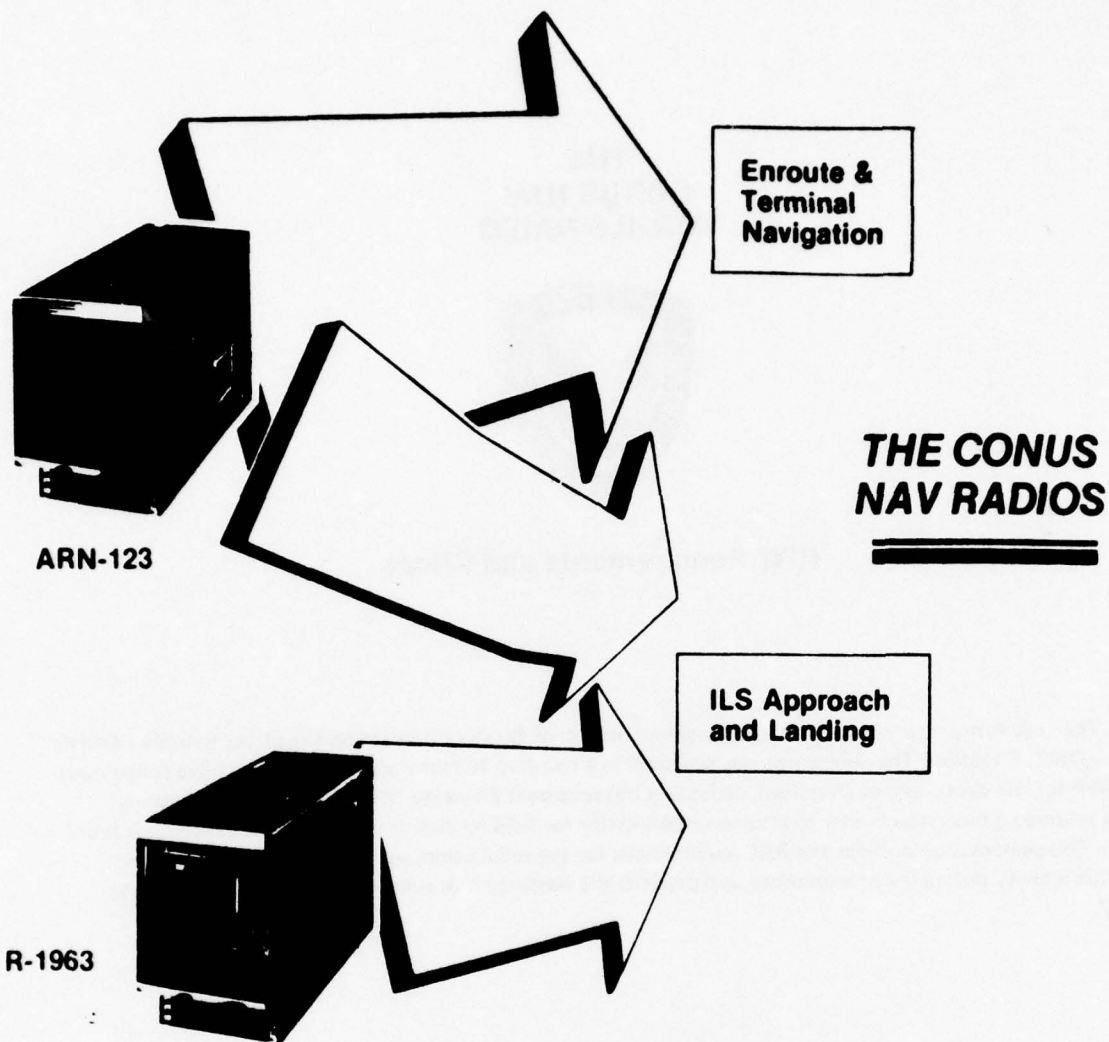
Dr. Kowalski is Manager of the System Acquisition Group in ARINC Research Corporation's Aircraft and Vehicles Division. This group works with various Project Offices in developing, applying, improving, and administering system acquisition tools and concepts — i.e., design-to-cost, life-cycle cost, and warranty. Typical programs include the AN/ARN-118(V) TACAN, the F-16 Air Combat Fighter, the Cruise Missile, and the Army's VOR/ILS Radio and Lightweight Doppler Navigation System (LDNS).

THE CONUS NAV VOR/ILS RADIO



RIW Requirements and Prices

The U.S. Army recently awarded the Avionics Division of Bendix Corporation a contract to build CONUS NAV VOR/ILS Radios. The equipment was procured in a two-step formally advertised competitive solicitation. The RFP for this procurement contained Reliability Improvement Warranty (RIW) Terms and Conditions which required a successful bidder to assume responsibility for field reliability and repair of each unit for four years. This presentation outlines the RIW requirements for the solicitation, summarizes warranty source-selection activity during the procurement, and presents the warranty bids submitted by the offerors during Step 2.

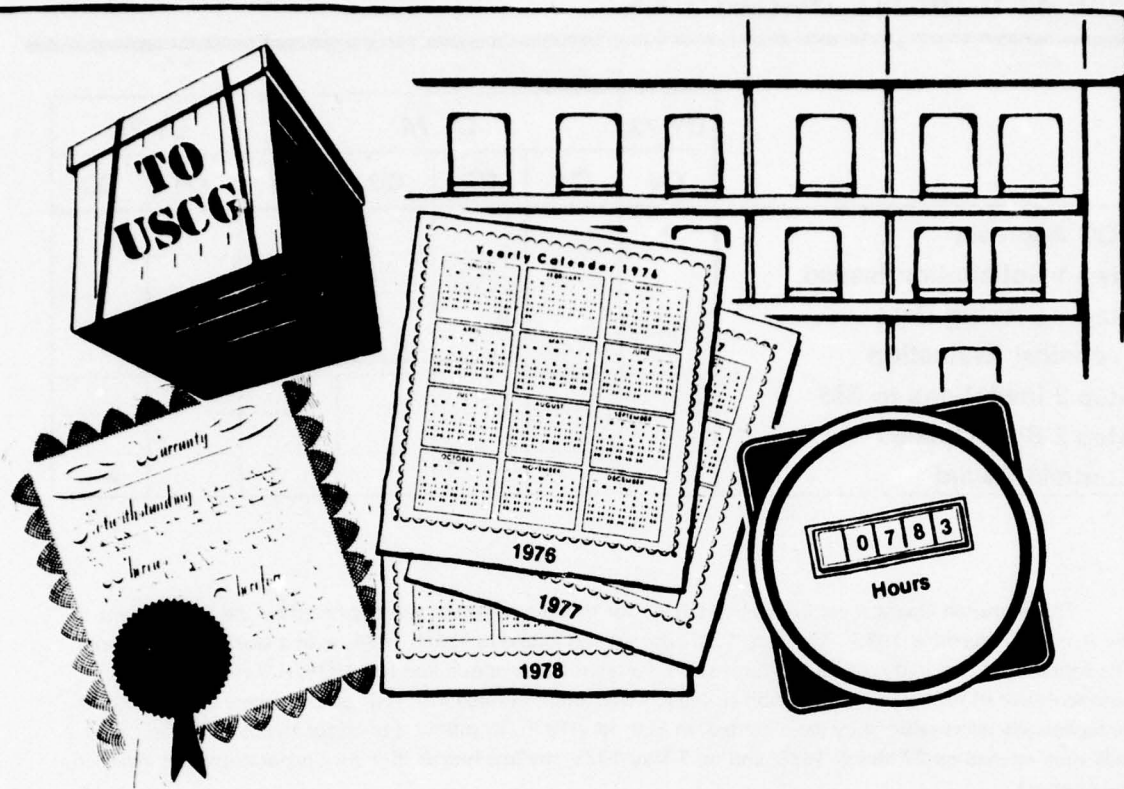


The CONUS NAV procurement will allow the Army to purchase up to 2300 AN/ARN-123 () V radio receiving sets and up to 930 R/1963 () /ARN Glideslope/Marker Beacon Receivers.

The ARN-123 Radio Receiving Set will provide Army aircraft equipped with appropriate instrumentation Very High Frequency Omnidirectional Range (VOR) bearing, Localizer (LOC), Glideslope (GS), and Marker Beacon (MB) position information for en route and terminal navigation and Instrument Landing System (ILS) approach and landing.

The R-1963 will provide glideslope and marker beacon information during ILS approach and landing. A complete VOR/ILS system is established when this unit interfaces with an updated AN/ARN-82 VOR/ILS Receiver.

PROCUREMENT FEATURES



A number of features of this procurement give it considerable visibility at the Army Materiel Command (AMC), Department of the Army (DA), and the Department of Defense (DoD). For example:

- Production deliveries will be spread over three calendar years if all options for the equipment are exercised.
- High-grade, commercial, off-the-shelf receivers are utilized for this nontactical application.
- Each receiver is covered by a four year reliability improvement warranty.
- A guaranteed operational MTBF is specified. Should the measured MTBF fall below the specified value, the contractor is required to perform additional Group C testing on all newly manufactured units at no additional cost to the Government.
- The procurement is bi-service because the Coast Guard has sent to the Army a Military Inter-departmental Procurement Requisition (MIPRI) for 275 of the ARN-123s.

PROCUREMENT SCHEDULE

	CY 73	CY 74				CY 75	
	Q4	Q1	Q2	Q3	Q4	Q1	Q2
ROC Approved	▲						
Step 1 Solicitation Issued		▲					
Step 1 Closing Date			▲				
Technical Evaluation			▲	—————▲			
Step 2 Invitations to Bid						▲	
Step 2 Bids Opened						▲	
Contract Award							▲

The Required Operational Capability (ROC) for this procurement was approved by the Department of the Army in November 1973. The Step 1 solicitation was issued in March 1974, with a closing date in April. The solicitation required that each offeror submit a technical proposal and two VOR/ILS radio receivers representative of his current production activity. After Step 1 evaluation, four offerors were determined to be technically acceptable; they were invited, in February 1975, to submit a price for the second step. Step 2 bids were opened on 27 March 1975; and on 7 May 1975, the low bidder, Bendix Corporation, was awarded the contract.



WARRANTY FEATURES

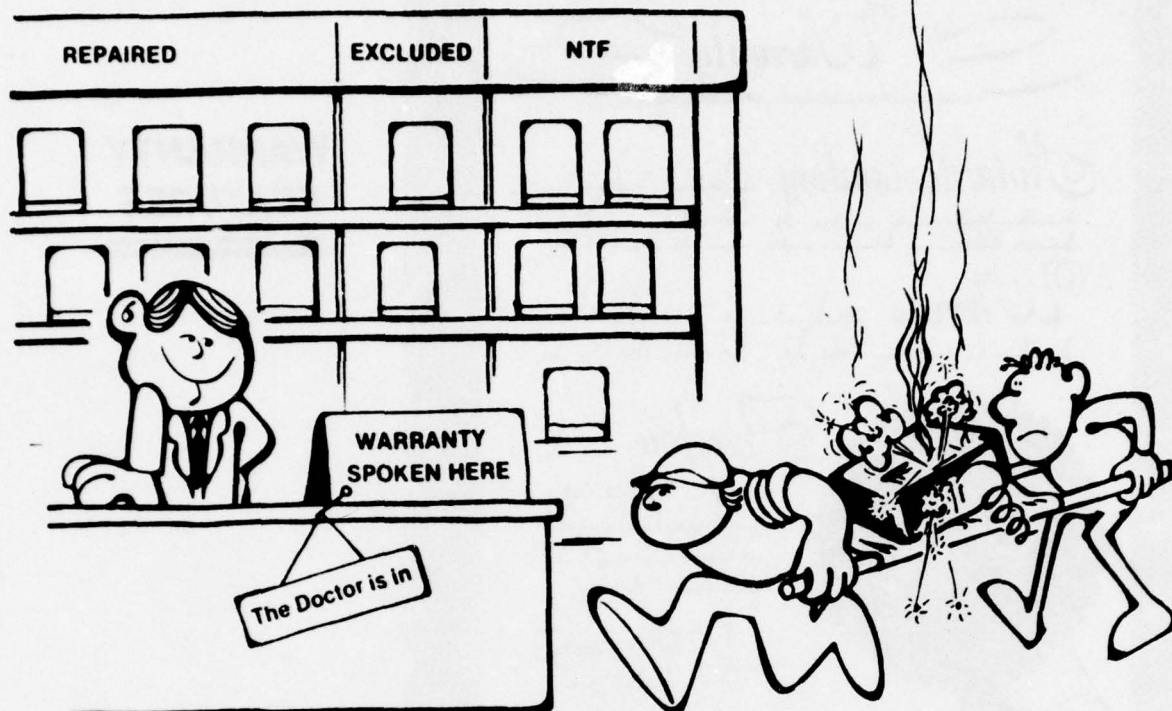
Each radio delivered under this contract is covered by a Reliability Improvement Warranty (RIW), and the next several slides address the major features of this warranty.

The warranty starts upon Government acceptance of a radio and extends for a period of 48 months from the end of the calendar quarter in which the radio was accepted.

Shipping Inventory Control. Two way shipping expenses are borne by the Government. Inventory control at the contractor's plant is handled through Form DD-1149.

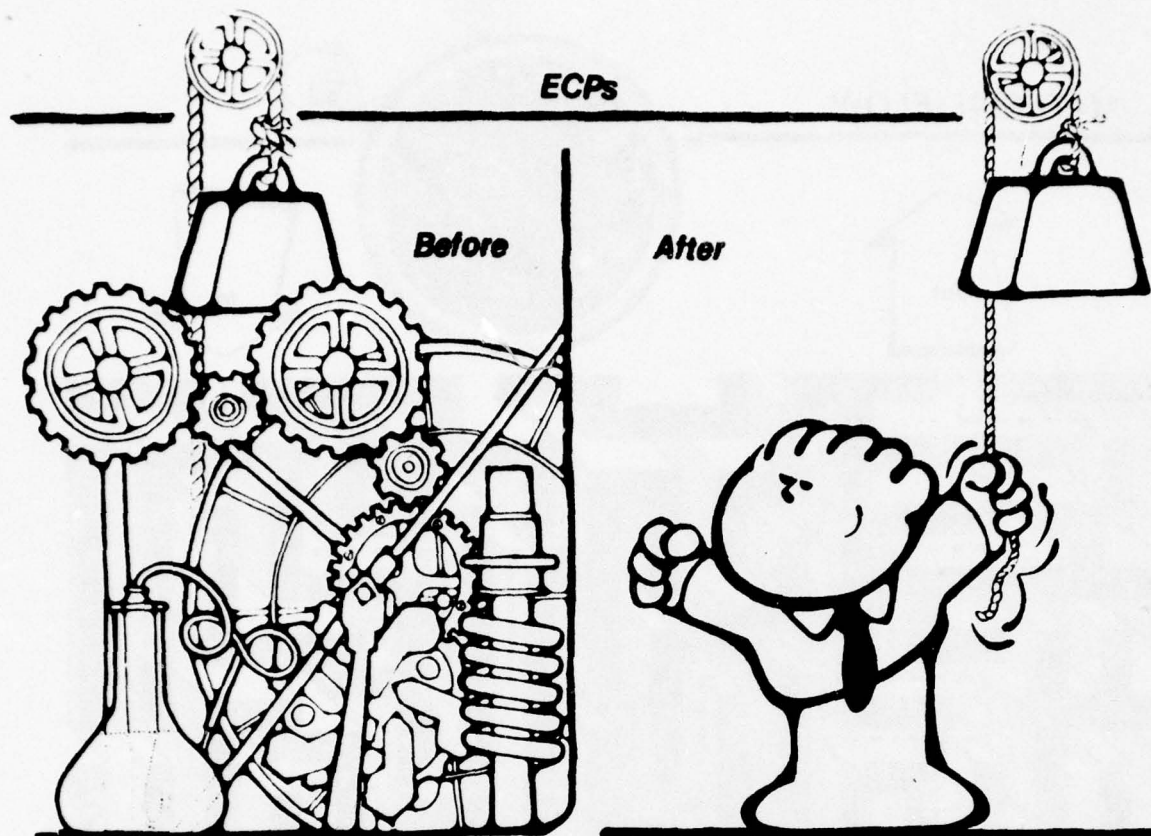
Government Obligations. To the extent possible, the government is required to test all suspected failures prior to return to the contractor, to furnish failure circumstance data, and to utilize approved shipping containers.

MAINTENANCE



The contractor is responsible to repair or replace each unit whose failure is not caused by fire, explosion, submersion, aircraft crash, enemy action, natural disaster, or accidental or wilful mistreatment. It is the contractor's responsibility to present clear and convincing evidence to substantiate any claim for release from warranty liability. The contractor is not liable for special or consequential damages. A separate contract will be written with the contractor to cover the cost of repairs for excluded returns.

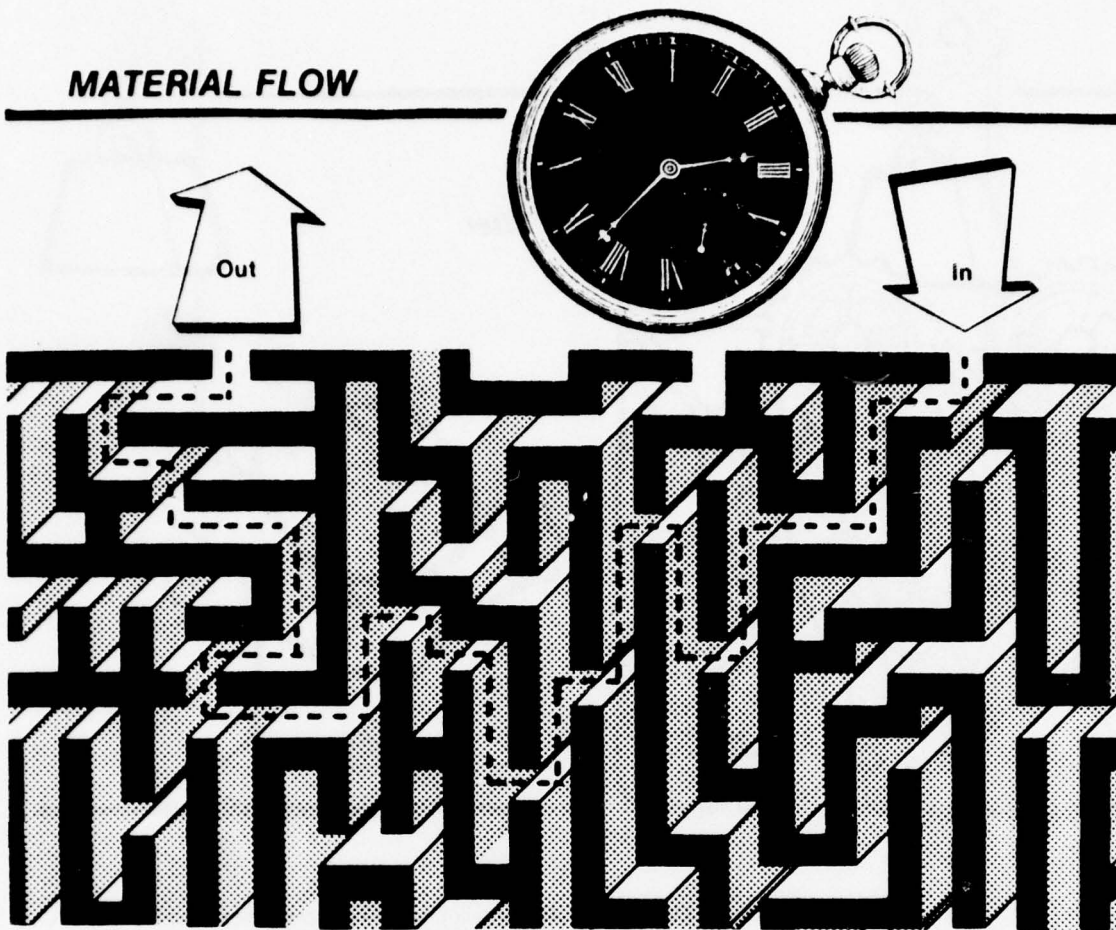
No Trouble Found (NTF). The contractor is reimbursed \$100.00 for each good receiver returned in excess of 30% of all returns in a reporting period. This 30% figure represents an estimate of the average number of no-trouble-found returns for this type of avionics.



The contractor is encouraged to submit ECPs for reliability/maintainability improvement at no change in contract price. MIL STD 480 processing procedures apply. Such ECPs, when approved, must be incorporated in all new production units and in prior production units returned for warranty services.

These conditions do not limit the contractor's privilege of submitting cost ECPs.

MATERIAL FLOW



A repair/return supply concept will be utilized for the CONUS NAV radios. Once they reach his repair facility, the contractor must complete all warranty repairs, install outstanding ECPs, and ship the unit to a designated Government facility within 20 calendar days. For each unit not shipped within 20 days, the contractor is assessed liquidated damages of \$10.00 per day for each day over 20.

GUARANTEED

Period #	Interval [months after initial production delivery]	MTBF [hours]	
		AN/ARN-123 []V*	R-1963/ARN
1	1-12	500	1000
2	13-24	600	1200
3	25-48	700	1400

*Excluding the control unit

This table shows guaranteed MTBF values specified for the VOR/ILS receivers. The MTBF guarantee is not part of the RIW but has been incorporated into the program as an added incentive for the contractor to meet reliability requirements. Operational MTBF estimates are to be made annually by using prescribed procedures.

In the event measured operational MTBF is less than the guaranteed MTBF, the contractor shall furnish, at no additional cost:

- Engineering analysis to determine the cause of the low MTBF
- Corrective engineering design changes to be implemented through no-change-in-price ECPs
- Additional Group C testing applicable to the receiver type for subsequent production units

DATA

- **MTBF Data Report [Annual]**
- **Warranty Effectiveness Report [Annual]**
- **Warranty Data Report [Quarterly]**

The contractor will provide warranty data in order to accomplish the following:

- Assess the effectiveness of the warranty provisions
- Calculate the contract price adjustments
- Perform reliability, maintainability, and logistics analyses

The MTBF data report will be used to estimate the operational MTBF of the radios.

The Warranty Effectiveness Report will contain the contractor's experiences and conclusions regarding effectiveness of the warranty concept for this contract.

The Warranty Data Report will describe warranty activity and will include detailed listings of warranty repair actions.

STEP ONE ACTIVITY

- **Review proposals**
- **Request clarification**
- **Project office review of warranty**
- **Revise warranty**
- **Request & evaluate Impact Statements**
- **Evaluate acceptability of warranty response**

The Step 1 solicitations were sent to 27 companies in March 1974. Six offerors submitted technical proposals and sample hardware in April. Warranty was a proposal-evaluation area. Each offeror's interpretation of the requirements and the consistency and credibility of his response were evaluated. The Project Office requested clarification of various warranty factors from the offerors.

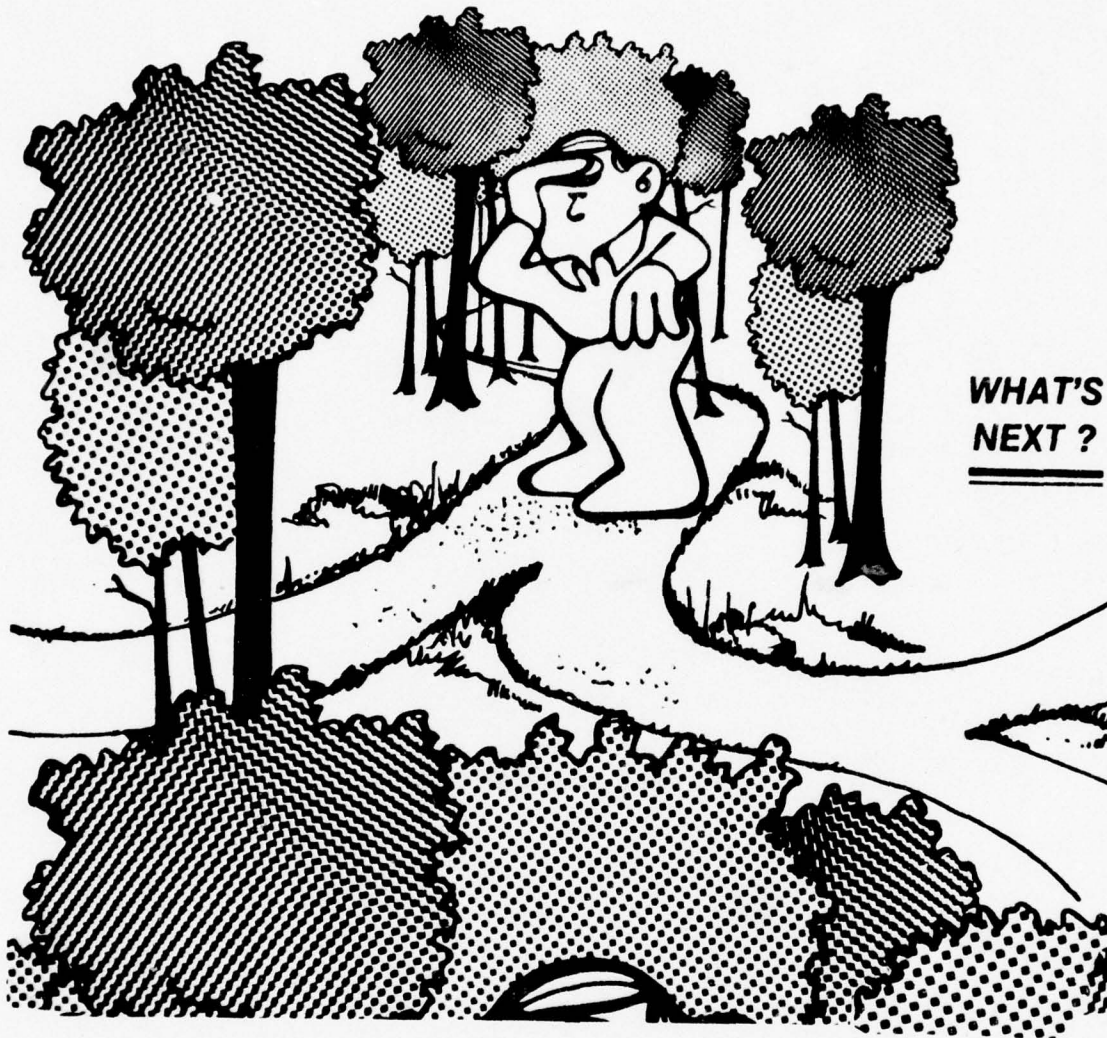
In June 1974, the Project Office held meetings to review the warranty provisions. A number of recommended changes in wording and scope of the warranty provisions were discussed, and several changes were adopted.

Major changes included ECP processing, turnaround time, and the addition of the MTBF guarantee. Minor modifications were made in several other areas. A revised set of provisions was sent to the offerors in July, with a request for an impact statement. After review of the replies, it was determined that each offeror's submittal was acceptable in the warranty area.

PRICES

	Acquisition (\$)		4 YR Warranty (\$)		Warranty Data [\$]
	ARN-123	R-1963	ARN-123	R-1963	
Bendix	1377	680	148 [2.5%/YR]	61 [2.3%/YR]	9800
Corp. X	2560	1275	598 [5.7%/YR]	265 [5.2%/YR]	11570
Corp. Y	4030	1750	462 [2.9%/YR]	232 [3.3%/YR]	66762
Corp. Z	NO BID				

This table summarizes the RIW-related prices submitted during Step 2. The first two columns contain unit acquisition prices for the ARN-123 and the R-1963, respectively. The next two columns contain the four-year per unit warranty costs for each radio. The bracketed figures are the warranty costs expressed as a percent per year of acquisition costs. The last column contains the price of those Contract Data Requirements Lists (CDRL) items which are required to support the warranty activity.



All that has been discussed in this presentation is only prologue to the true test for the Army of RIW for the VOR/ILS equipment: that is, how well does it work — for the user, for the item manager, for the contractor. Current schedules indicate that initial production units will be delivered in May 1976. This concept will be new to the activities using and handling the VOR/ILS equipment. The project office realizes that extra management skills and resources will be necessary to provide the proper environment for testing this concept. The project office has also tasked the ECOM Systems Analysis Office to provide a study plan for analyzing the effectiveness of the RIW for the CONUS NAV radios.

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**INERTIAL GYRO LIFE CYCLE COSTS
ANALYSIS AND MANAGEMENT**

by

Peter J. Palmer

**Charles Stark Draper Laboratory
Cambridge, Massachusetts**

OVERALL OBJECTIVE

EVALUATE LIFE CYCLE COST OF INERTIAL GYRO
PRODUCTION AND REPAIR

3-40

7507H389-2



CONSTRAINTS

- SEALED IMUS
- THREE GYROS PER IMU
- ONE GYRO FAILURE PER IMU

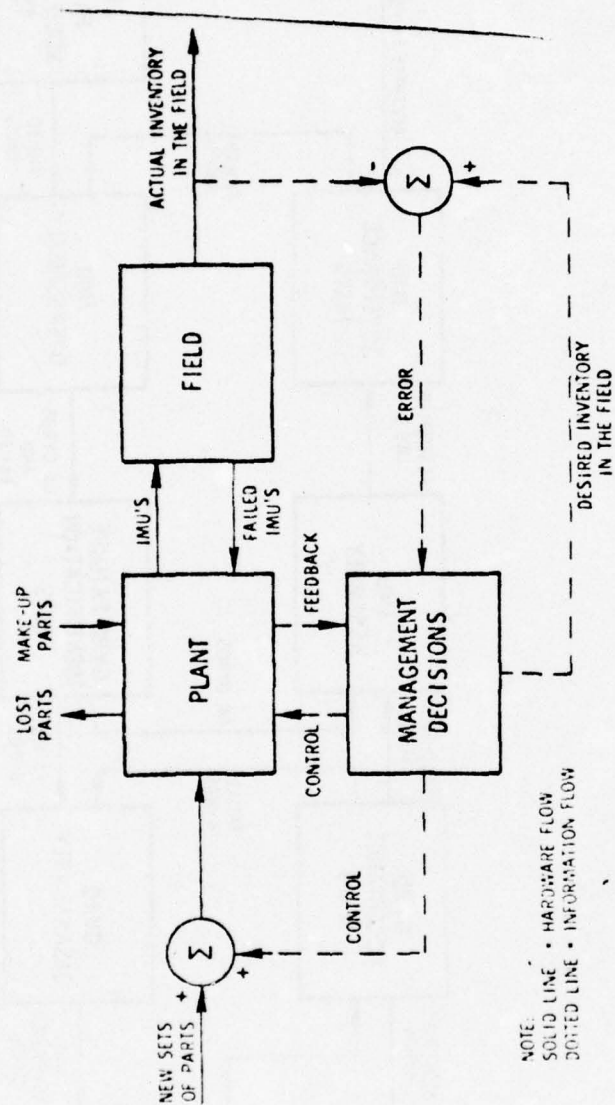
3-42

7507H389-4

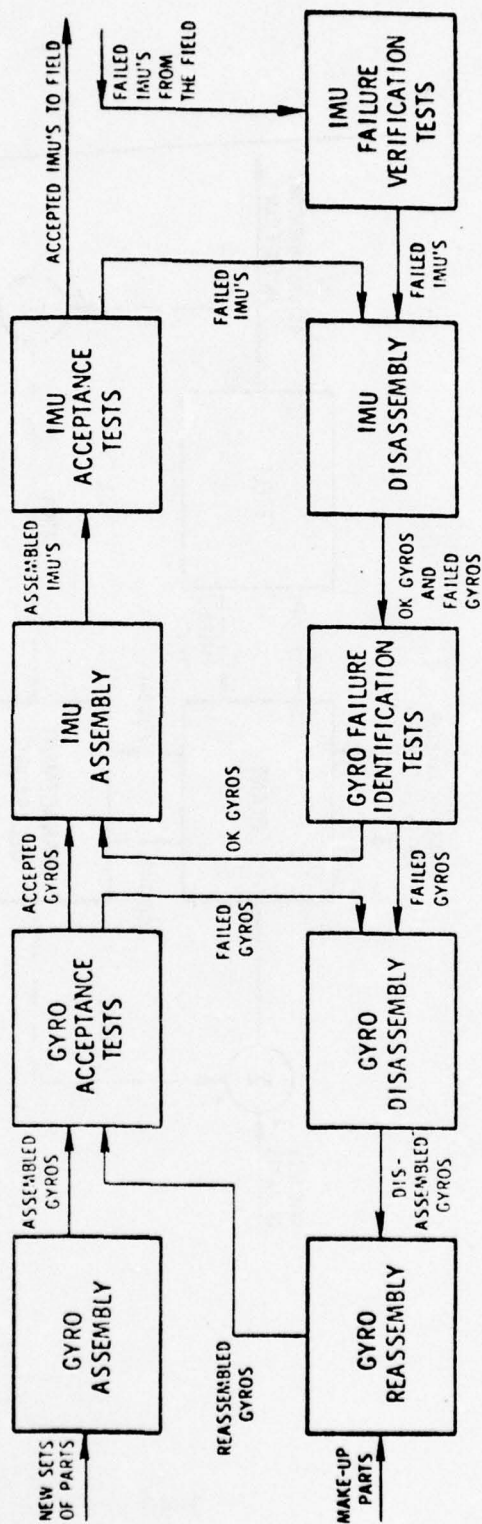


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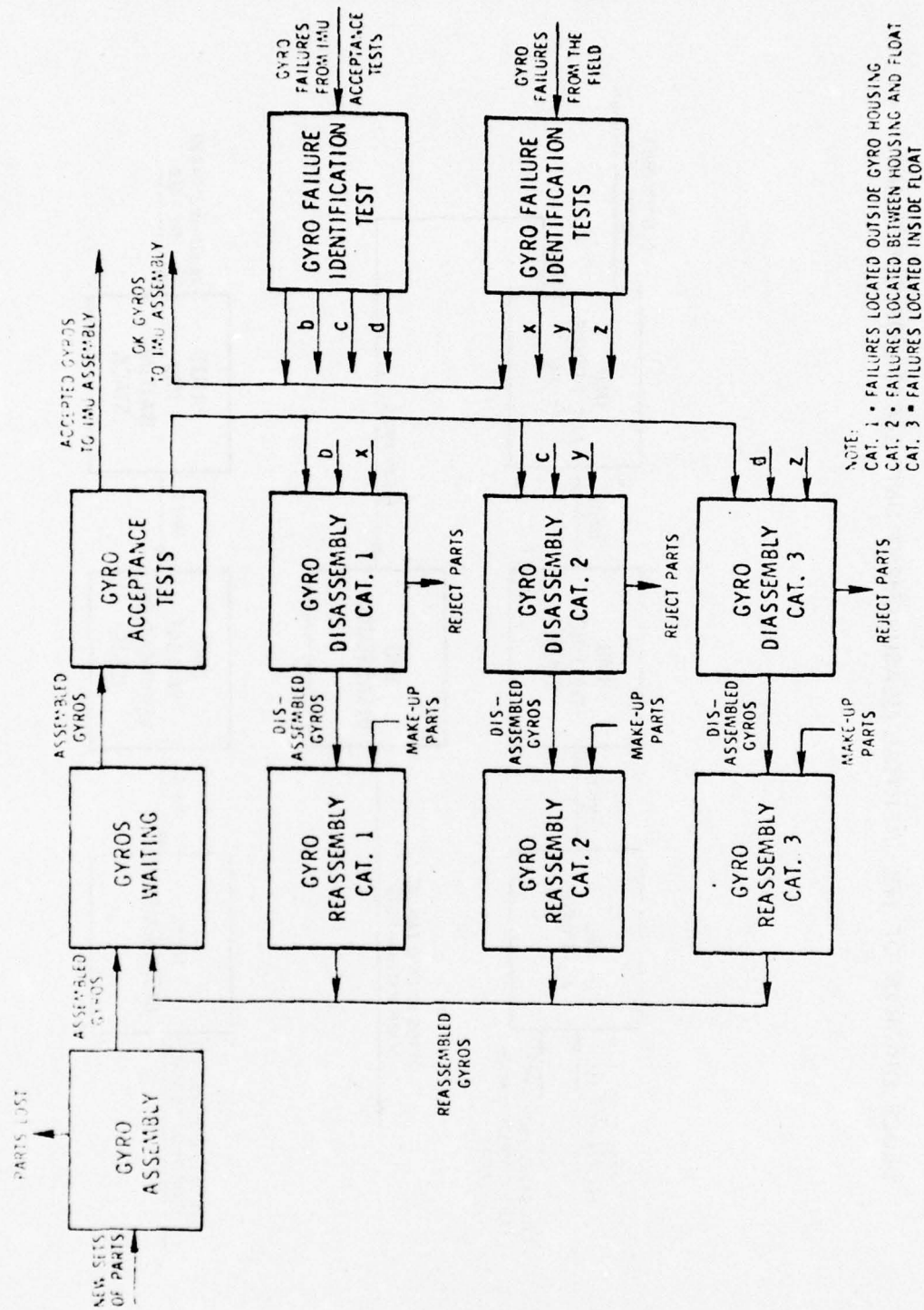
GYRO BUILD AND REPAIR CYCLE



BLOCK DIAGRAM OF THE PLANT

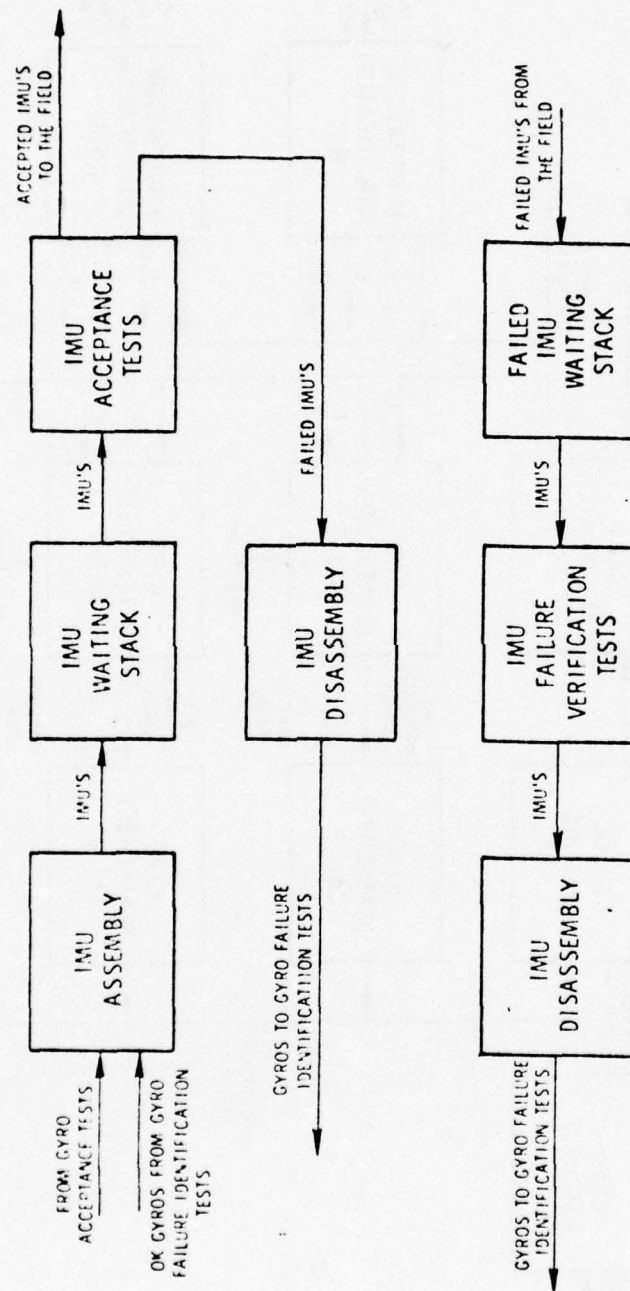


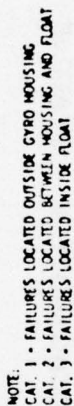
BLOCK DIAGRAM OF THE GYRO SECTOR OF THE PLANT



75074389-7

BLOCK DIAGRAM OF THE INERTIAL MEASUREMENT UNIT SECTOR OF THE PLANT





A MODEL EQUATION EXAMPLE

THE NUMBER OF GYROS WAITING FOR ACCEPTANCE TEST AT ANY GIVEN TIME IS
EQUAL TO THE LEVEL AT THE PREVIOUS TIME PLUS THE INFLOW OVER THE PREVIOUS
PERIOD MINUS THE OUTFLOW OVER THE PREVIOUS PERIOD.

$$\text{GYROAT.K} = \text{GYROAT.J} + (\text{DT})(\text{GYROTT.JK} - \text{GYACC.JK} - \text{GYNACC.JK})$$

WHERE

GYROAT.K = NUMBER OF GYROS IN ACCEPTANCE TEST AREA AT TIME K

GYROAT.J = NUMBER OF GYROS IN ACCEPTANCE TEST AREA AT TIME J

DT = ITERATION TIME INTERVAL IN DAYS

GYACC = RATE OF GYROS ACCEPTED IN GYROS/DAY

GYNACC = RATE OF GYROS NOT ACCEPTED IN GYROS/DAY

REFS: "DYNAMO USER'S MANUAL" BY A. PUGH
"INDUSTRIAL DYNAMICS" BY JAY FORRESTER



X
X
X
X
X

GYRO TIME AND COST PARAMETERS

OPERATION	ELAPSED TIME IN DAYS	LABOR COST	MATERIAL COST	TOOLS AND EQUIPMENT FOR 5 GYROS/DAY	YIELD
		DOLLARS/GYRO			
GYRO ASSEMBLY (NEW SETS)	30	5000	7000	\$1,042,000	
GYRO REASSEMBLY - CAT. 1 CAT. 2 CAT. 3	9	600	400	↓ \$1,042,000	
	15	2000	1000		
	30	4000	2800		
GYRO DISASSEMBLY - CAT. 1 CAT. 2 CAT. 3	NA	100	NA		
	7	500	NA		
	10	1200	NA		
GYRO FAILURE - IDENTIFICATION TESTS - CAT. 1 CAT. 2 CAT. 3 "GOOD"	7	300	NA		
	8	700	NA		
	8	1000	NA		
	7	1000	NA		
GYRO ACCEPTANCE TESTS	25	2000	NA	7.5 x 10 ⁶	0.7
IMU ASSEMBLY (GYRO PORTION)	7	300	NA	NA	
IMU DISASSEMBLY	7	200	NA	NA	
IMU FAILURE-VERIFICATION TESTS (GYRO PORTION)	12	400	NA	NA	
IMU ACCEPTANCE TESTS (GYRO PORTION)	12	2000	NA	NA	0.9



DEFINITIONS FOR GRAPHIC OUTPUT

GYROAS = G NUMBER OF GYROS IN GYRO ASSEMBLY AREA

TLGDIG = D NUMBER OF GYROS IN GYRO DISASSEMBLY AREA

TLGREAS = R NUMBER OF GYROS IN GYRO REASSEMBLY AREA

GYROAT = T NUMBER OF GYROS IN ACCEPTANCE TEST AREA

IMUASS = S NUMBER OF GYROS IN IMU ASSEMBLY AREA

IMUDIS = A NUMBER OF IMU'S IN IMU DISASSEMBLY AREA

IMUTTA = B NUMBER OF IMU'S IN IMU ACCEPTANCE TEST AREA



RESULTS

- FOR THE REFERENCE EXAMPLE*

<u>ITEM</u>	<u>PERCENT OF LIFE CYCLE COST</u>
LABOR	67
PARTS AND MATERIALS	28
TOOLS AND TEST EQUIPMENT	5
	<hr/> 100%

*WHERE GYRO YIELD = 0.7, IMU YIELD = 0.9, IMU FAILURE RATE = 0.5/YR



RESULTS (CONTINUED)

- LCC IS SENSITIVE TO IMU RELIABILITY
- DYNAMIC BEHAVIOR OF SYSTEM IS SENSITIVE TO GYRO AND IMU ACCEPTANCE TEST YIELD
- LCC IS REDUCED BY IDENTIFYING FAILURES AT LOWEST POSSIBLE LEVEL OF ASSEMBLY
- LCC IS REDUCED 1% WHEN IMU ACCEPTANCE TEST YIELD IMPROVES 1%*
- LCC IS REDUCED 0.3% WHEN GYRO ACCEPTANCE TEST YIELD IMPROVES 1%*
- GYRO ASSEMBLY COST IS 27% OF THE LCC*


*FOR THE REFERENCE EXAMPLE



RECOMMENDATIONS

- INCLUDE TIME IN LCC MODEL
- STUDY DYNAMIC BEHAVIOR OF MODEL
- IDENTIFY COST-PRODUCING CONSTRAINTS IN FACTORY OR FIELD
- GIVE SPECIAL ATTENTION TO RDT&E PHASE OF MODEL
- CONSIDER AUTOMATION IN INERTIAL GYRO PRODUCTION & REPAIR
- CAREFULLY DESIGN ACCEPTANCE AND DIAGNOSTIC TESTS
- PROVIDE ADEQUATE TEST EQUIPMENT





*Failure Free Warranty
Reliability Improvement
Warranty. buyer viewpoints!*

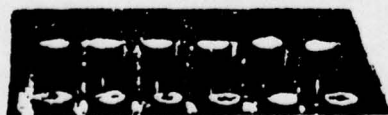
*presented by
Oscar Markowitz*

used in procurements...

- **SELECT A CONTRACTOR**
- **SELECT AN OPTION**

EVALUATION

$$\frac{Q (\text{BID PRICE} + \$29 + \text{SHIP COST} + \text{TESTING COST} - \text{DISCOUNT})}{Q (\text{CYCLES OFFERED})}$$



N00383-70-C-0678

→ \$0.935/CYCLE



N00383-73-C-0856

→ \$0.977/CYCLE

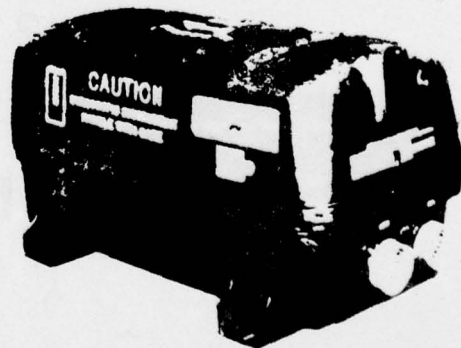
6 YEAR COST TO MAINTAIN
TOTAL ENGINE HOURS



N00383-73-C-3318
\$2.19/ENGINE HOUR

LCC EVALUATION

5 year cost to maintain
1,200,000 hours



N00383-67-C-3101	\$246/operating hours
N00383-73-C-3537	\$2.08/operating hours

EFW/RIW is contracting... with

- LONG TERM FIXED PRICE
- WARRANTY
 - REPAIR ALL FAILURES
 - CONTINUOUS RELIABILITY IMPROVEMENT
 - NO COST ECP's
- INHERENT REWARD OR PENALTY
- CLOSED LOOP
 - DATA
 - SUPPORT
 - REACTION TO FIELD EXPERIENCE

warranty involves:-

- ALL FIELD FAILURES
- EXTENDED PERIODS

2 FEW PRINCIPLE

RISKS

fixed cost
share reward/penalties
serial number management
damage
murder failure

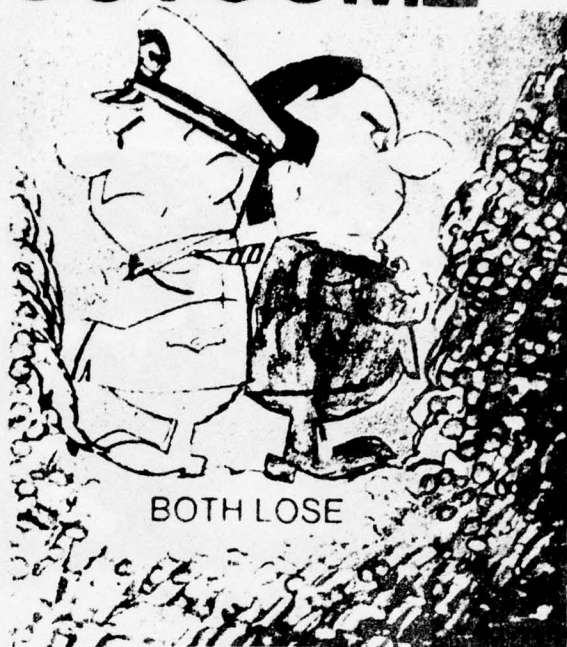
RELIABILITY

after hardware acceptance
field operation
no cost ECP
profit role

FFW OUTCOME



BOTH WIN



BOTH LOSE

BUYER BEWARE!

- MIL-Q-9858

- FFW/RIW

contractors
responsibility

FFW/ RIW Cost Avoidances



Both Win!

LEAR SIEGLER GYRO

\$ 3,000,000 +

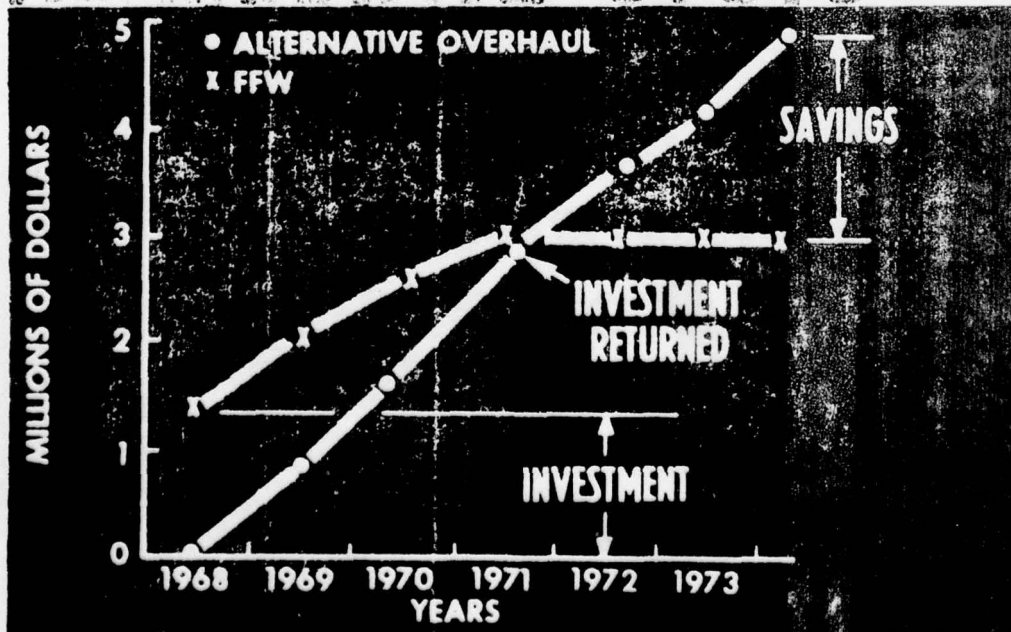
ABEX HYDRAULIC PUMP

\$ 130,000 +

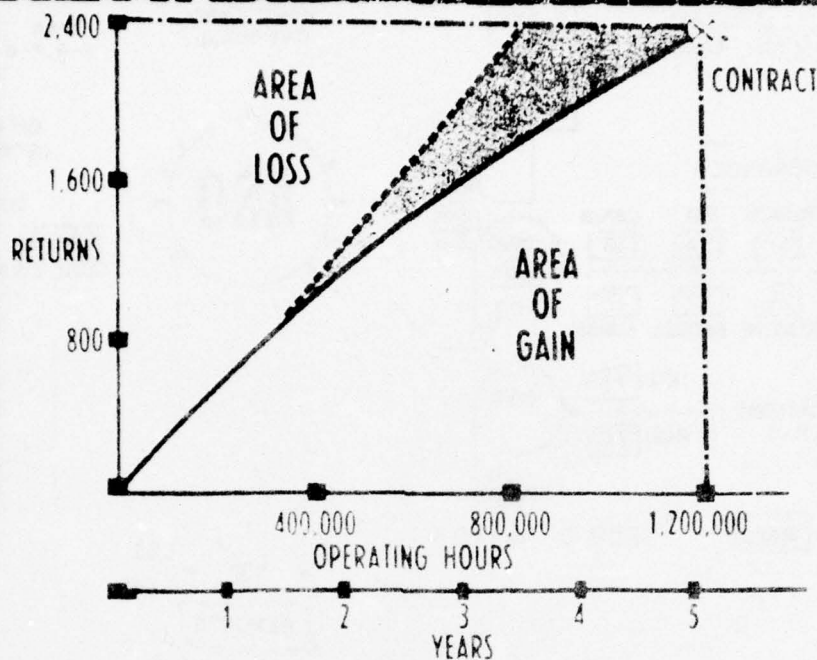
UTE RADAR TRANSPONDER

\$ 300,000 +

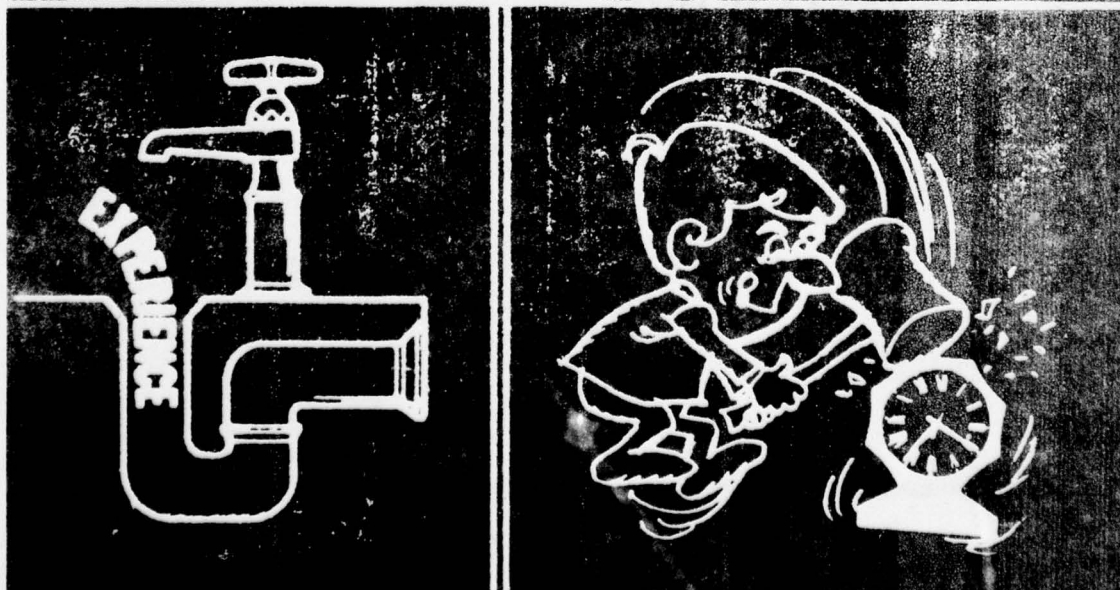
ALTERNATIVE COSTS



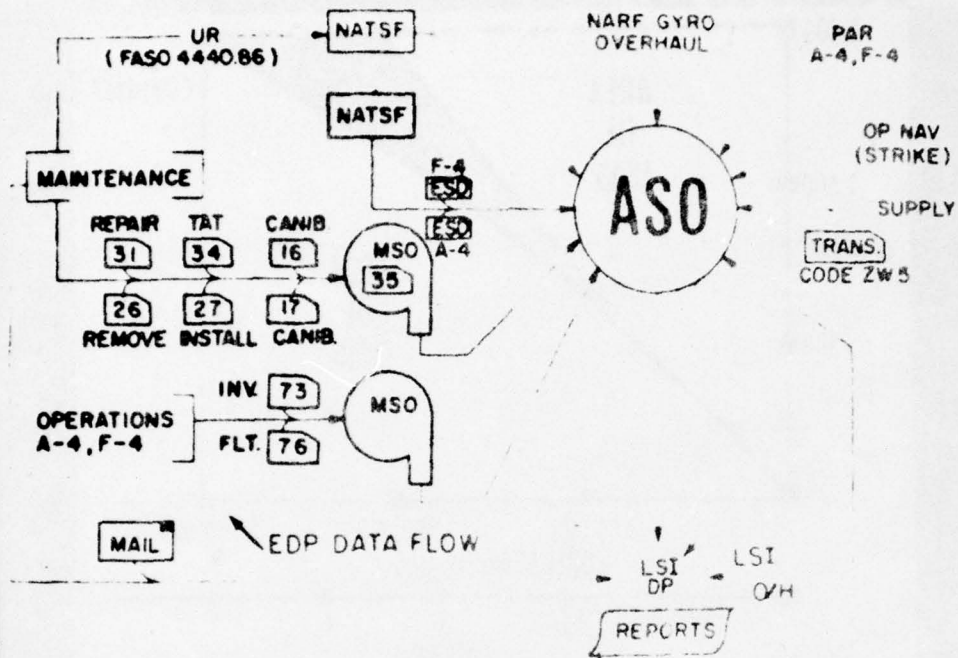
REWARD/PENALTY



CLOSE THE LOOP



INFORMATION FLOW



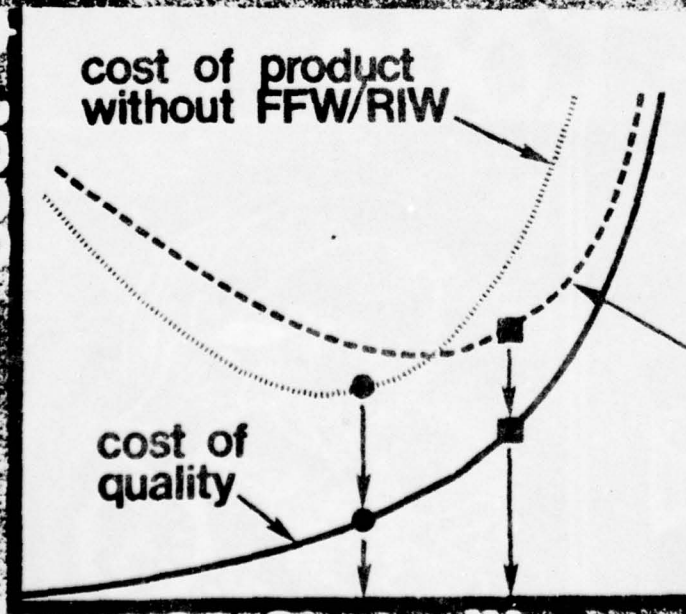
cost

cost of product without FFW/RIW

cost of product with FFW/RIW

cost of quality

level of quality



AD-A033 418

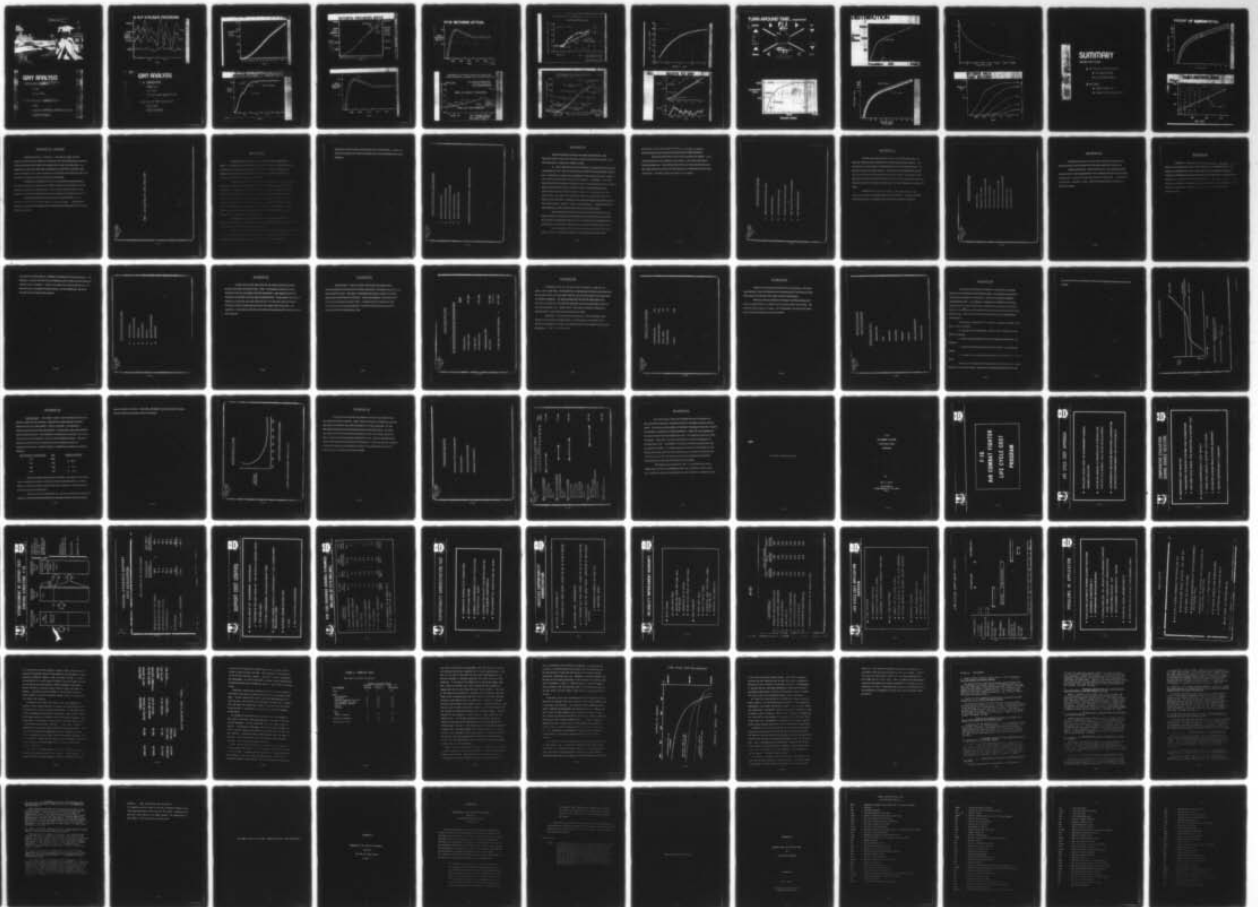
FAIRCHILD CAMERA AND INSTRUMENT CORP MOUNTAIN VIEW CA--ETC F/G 17/7
PROCEEDINGS OF THE LIFE CYCLE COST TASK GROUP OF THE JOINT SERV--ETC(U)
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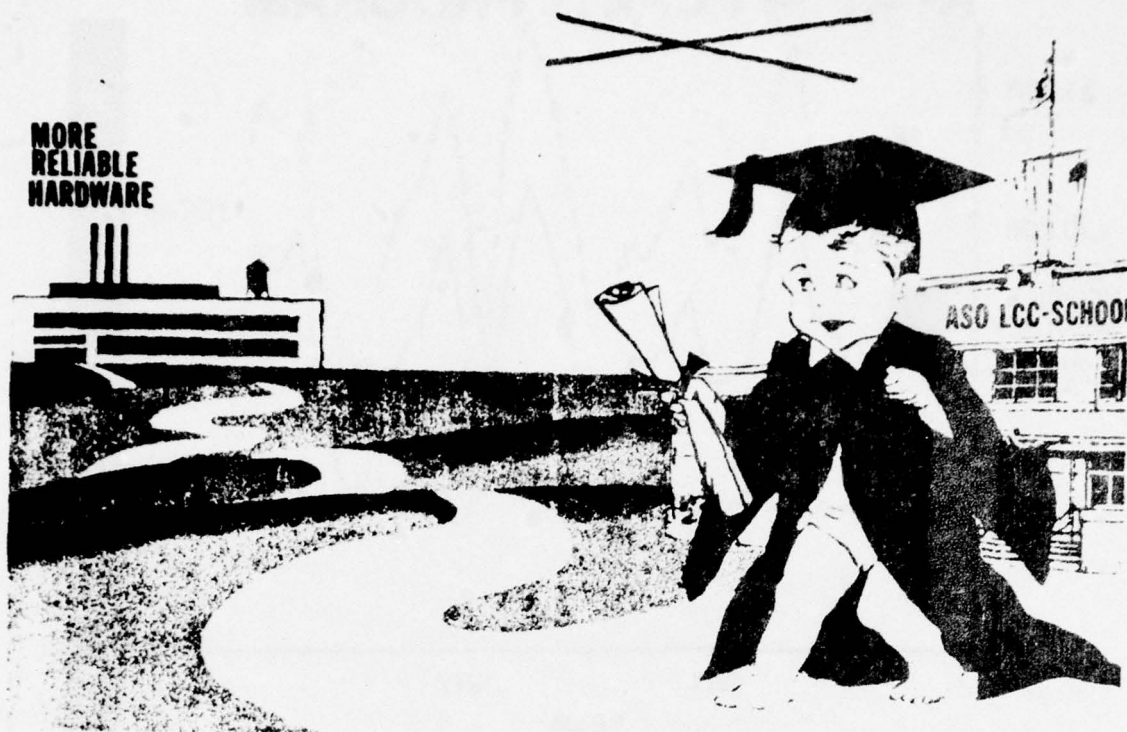
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2 OF 3
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WHY ANALYSIS

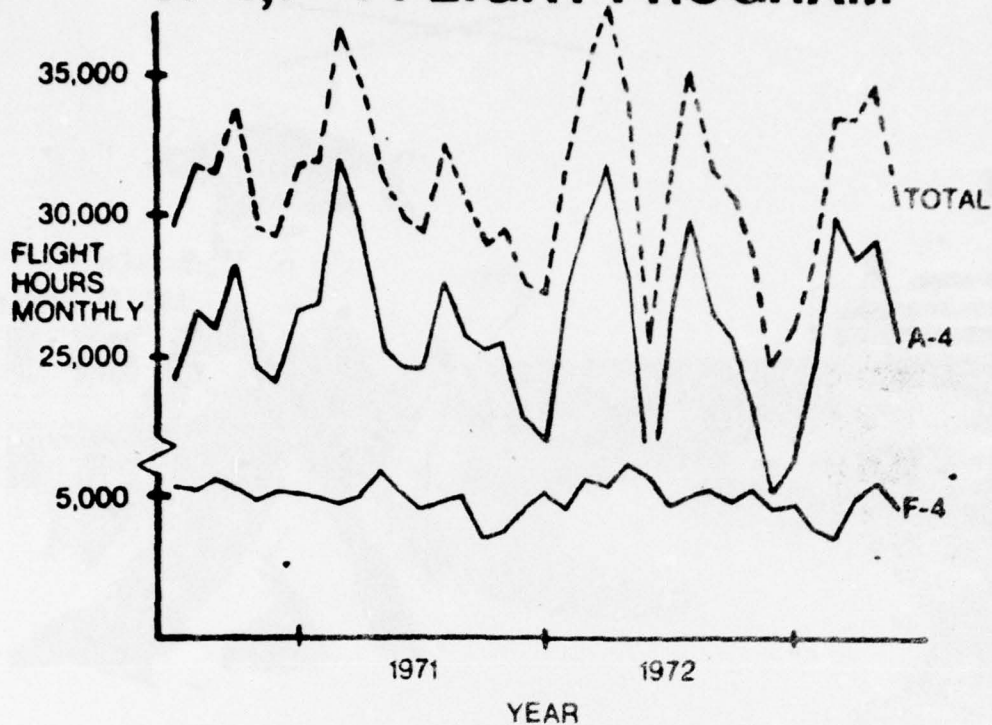
1. REQUIRE COSTS

- FFW
- NON FFW

2. ESTABLISH CONFIDENCE

- ADP
- CONTRACTORS APPROACHES
- VERIFICATION

A-4, F-4 FLIGHT PROGRAM



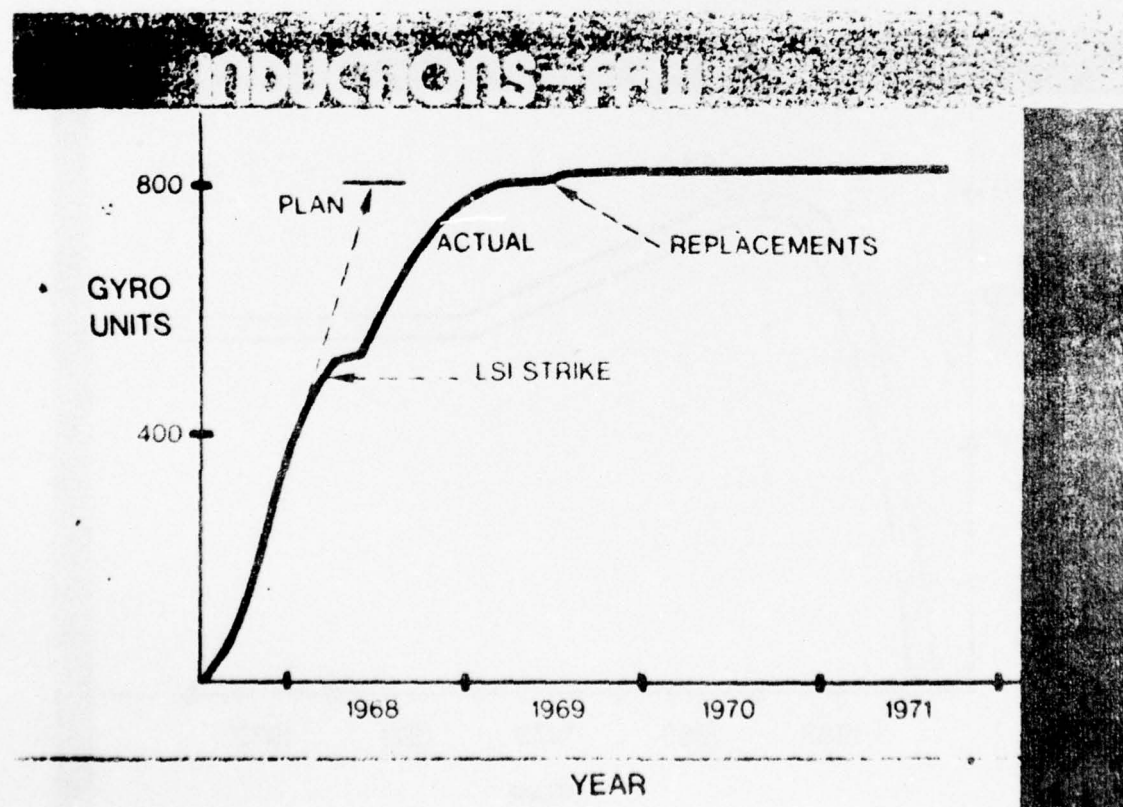
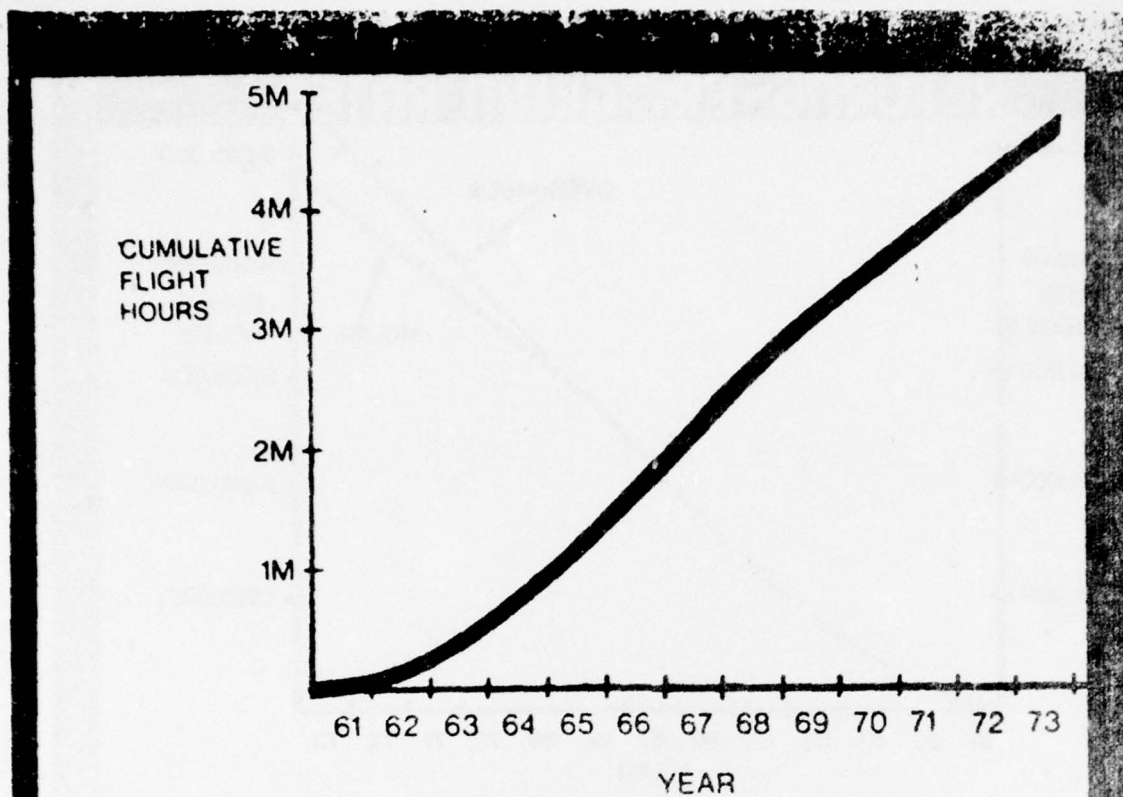
WHY ANALYSIS

3. ALTERNATIVE

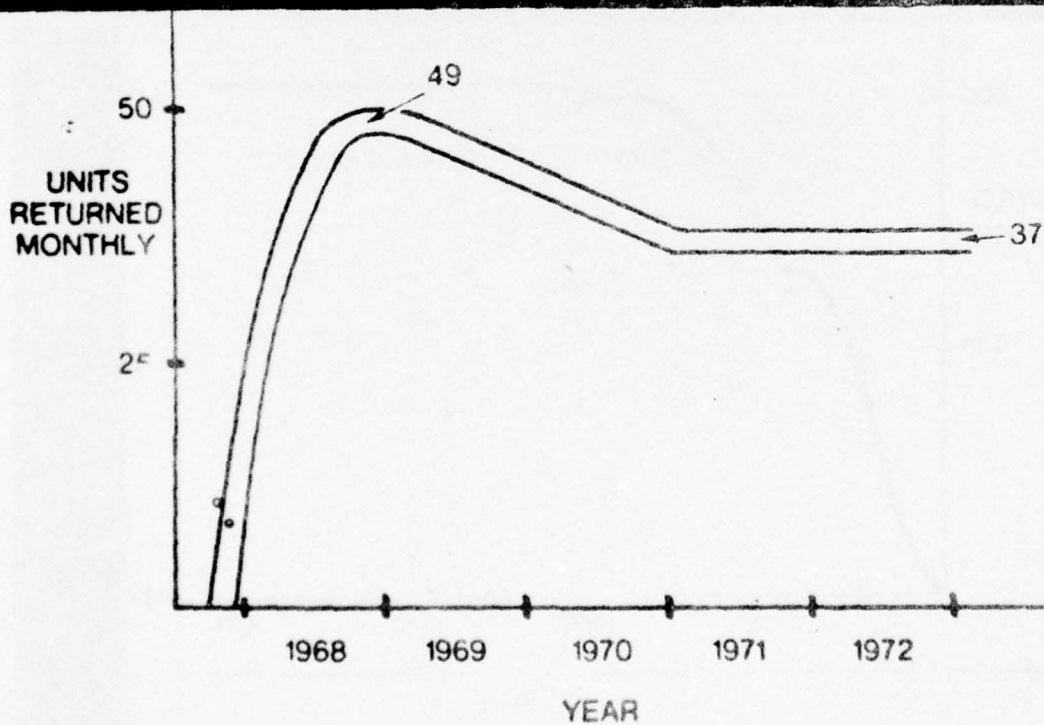
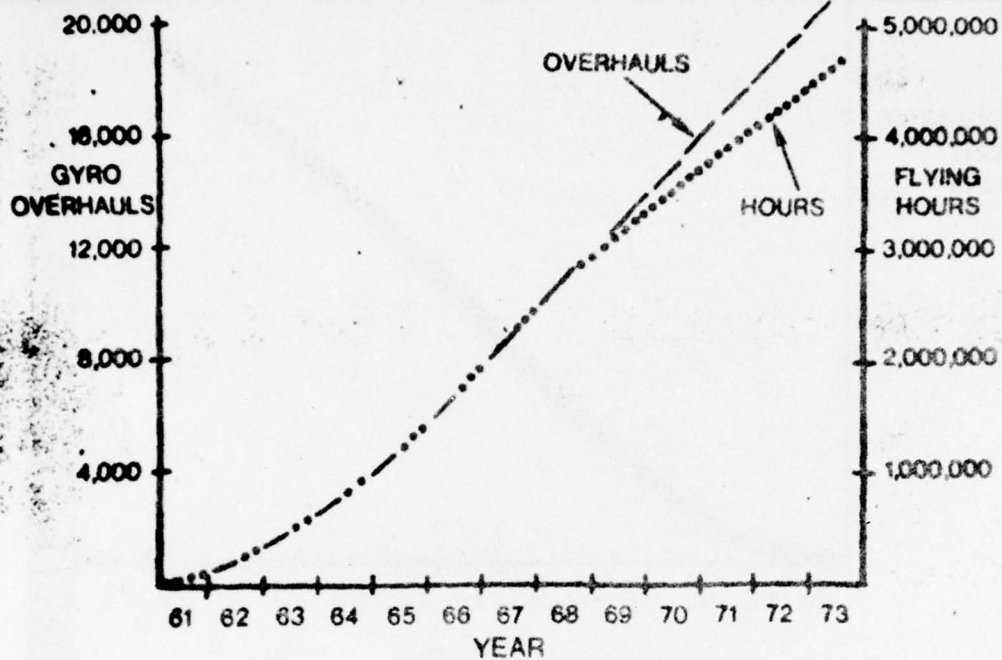
- CHECKS
- NO ADP
- OTHER ADP METHODS

4. DEVELOP TECHNIQUES

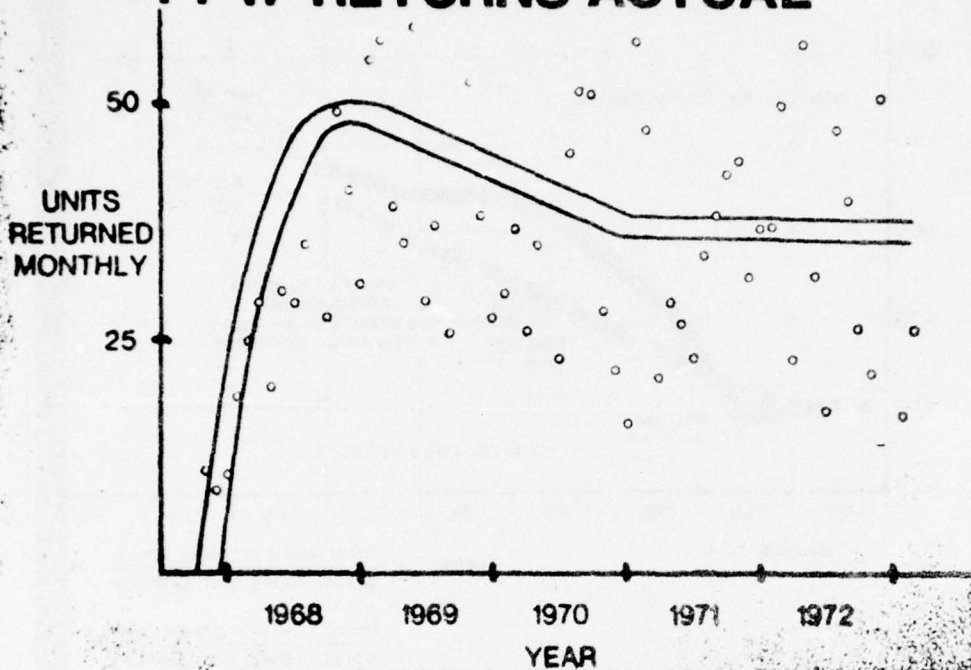
- DISPLAY
- INDICATORS



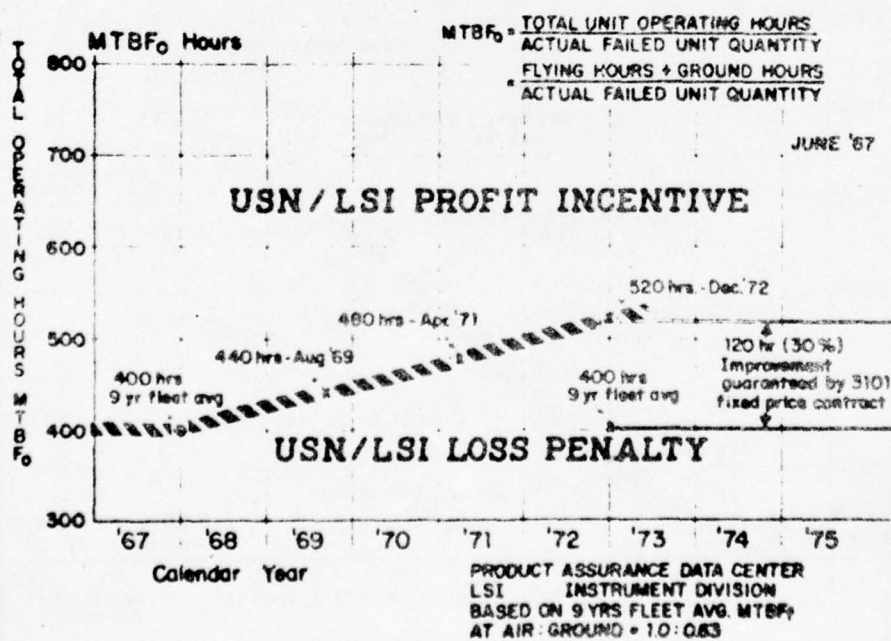
RETURNS-PROGRAM RATES



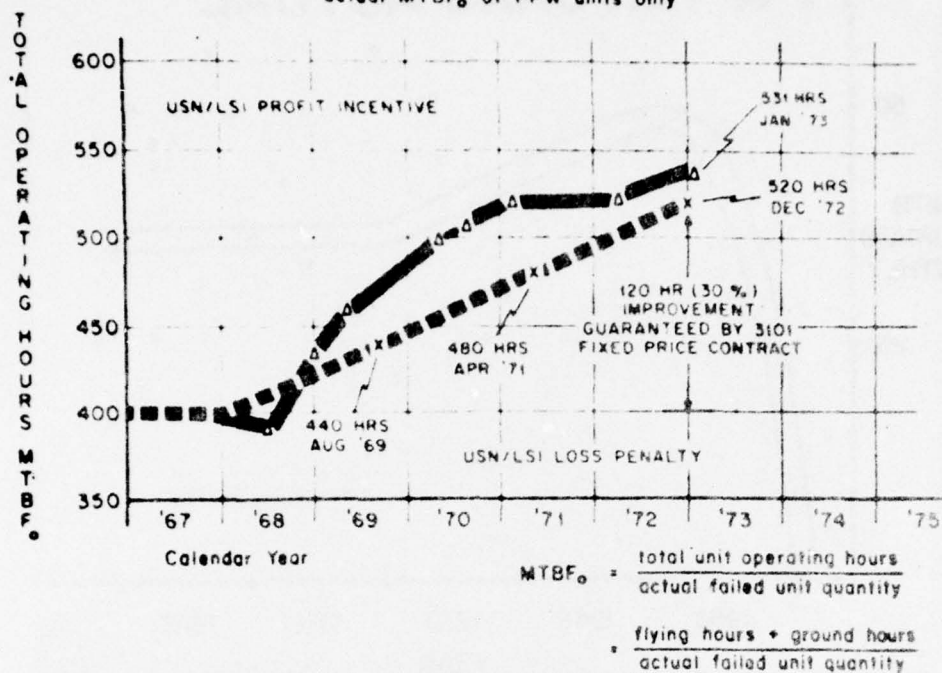
FFW RETURNS ACTUAL



USN/ASO LSI/ID Failure Free Warranty Contract 3101
Predicted MTBF₀ mean time between failures in A4 & F4 fleet operations



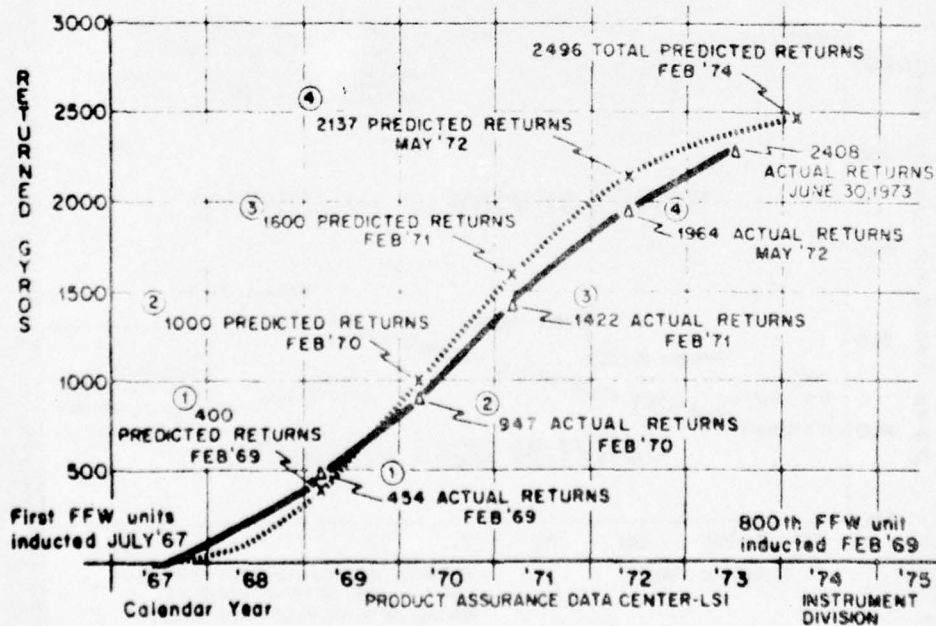
Predicted MTBF₀ meantime between failures in A4 and F4 fleet operations
VS
actual MTBF₀ of FFW units only

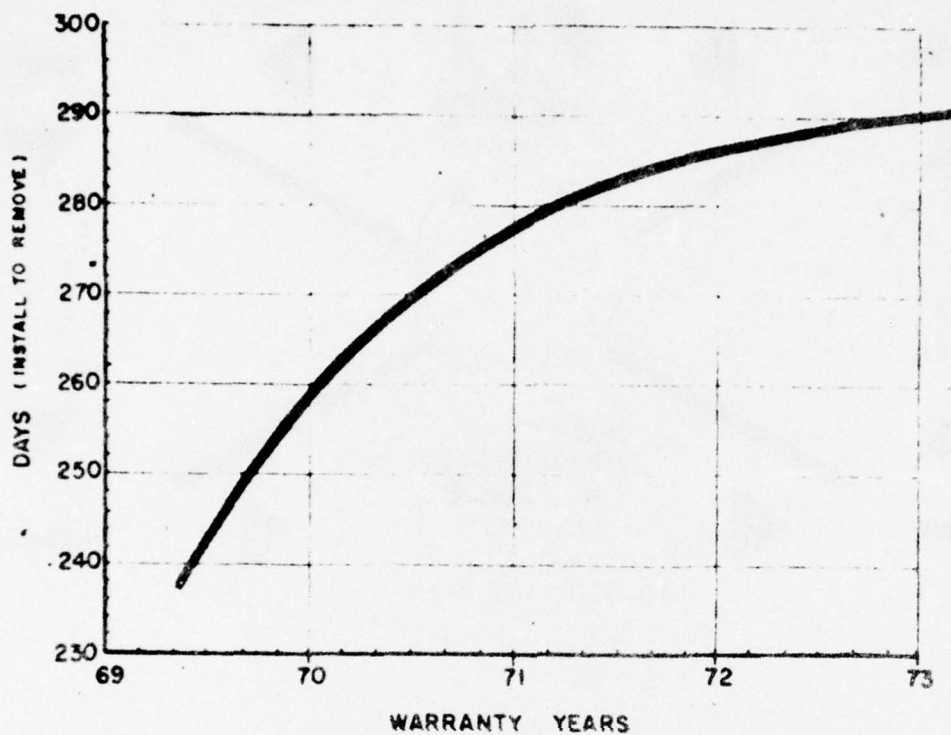


2171P/CN494A FFW PROGRAM CONTRACT 3101

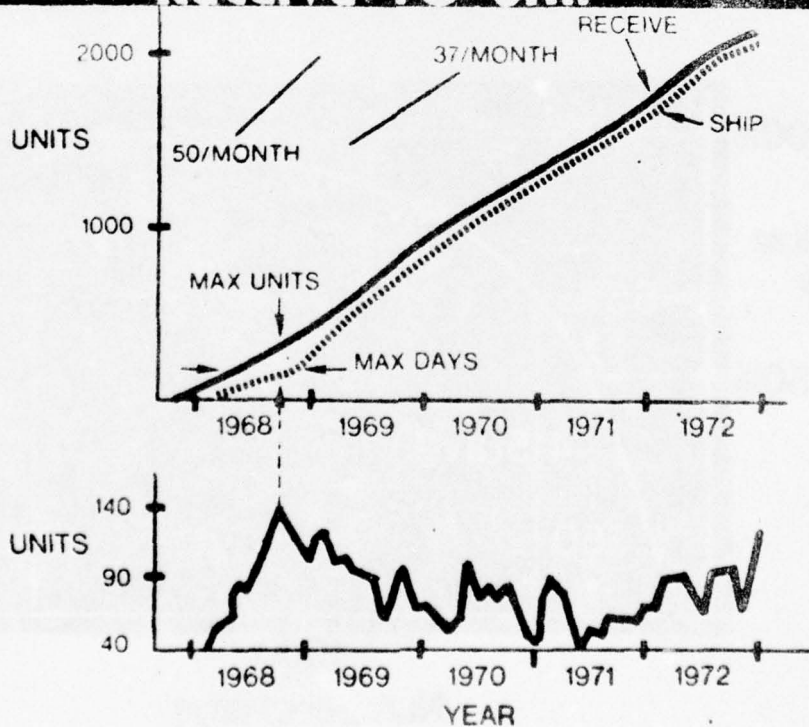
(JUNE '67)

Predicted vs Actual May '72 Gyro Returns

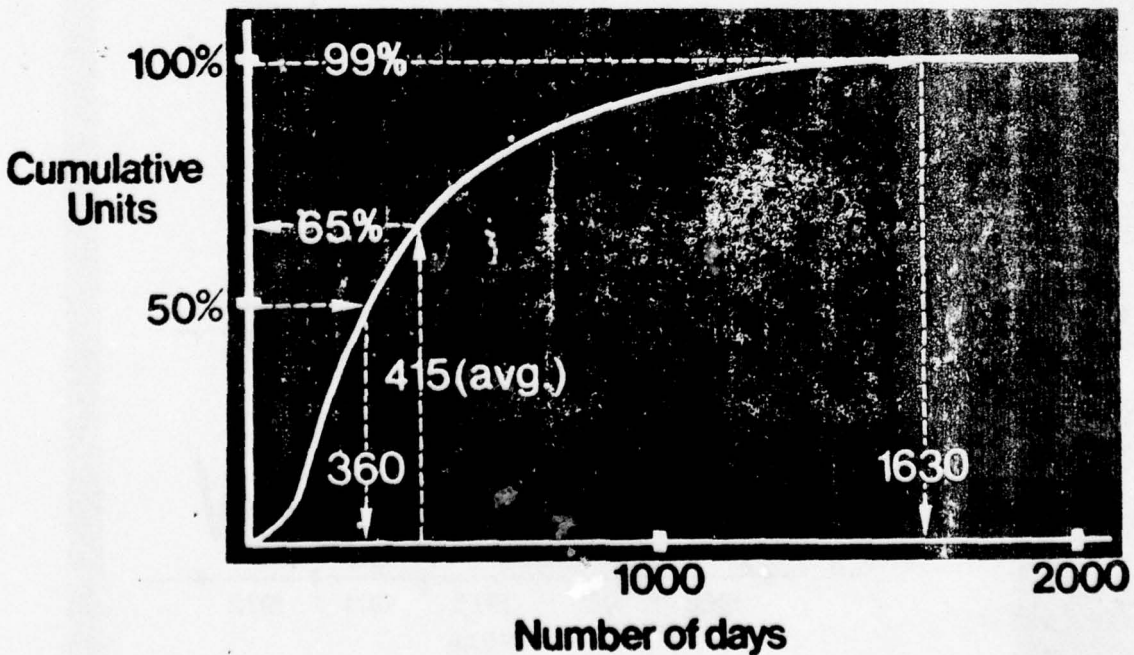
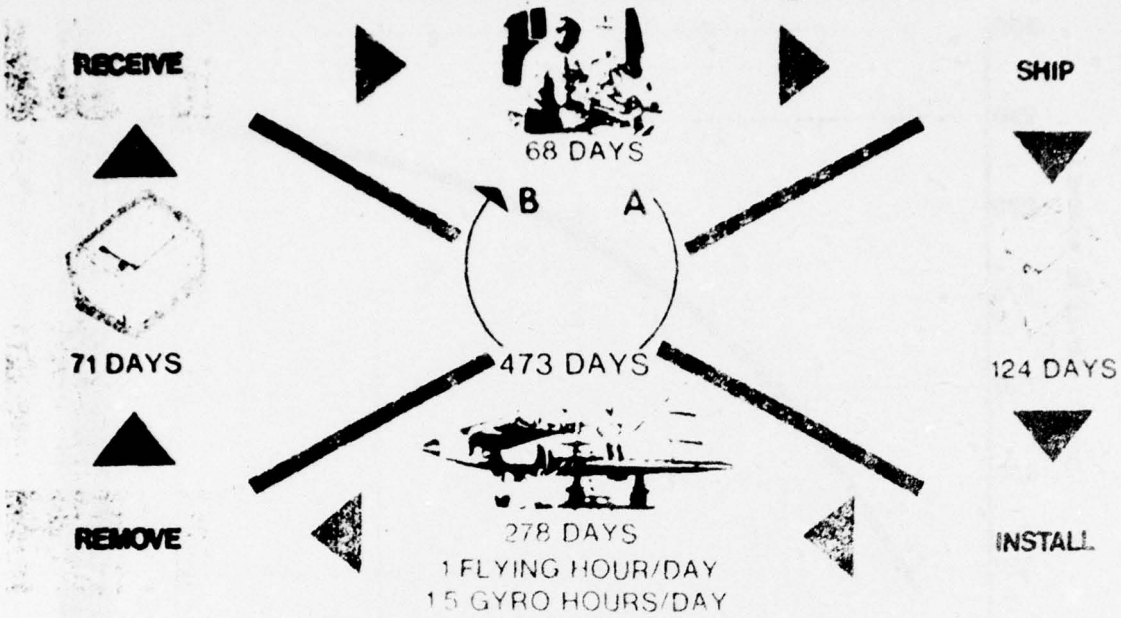




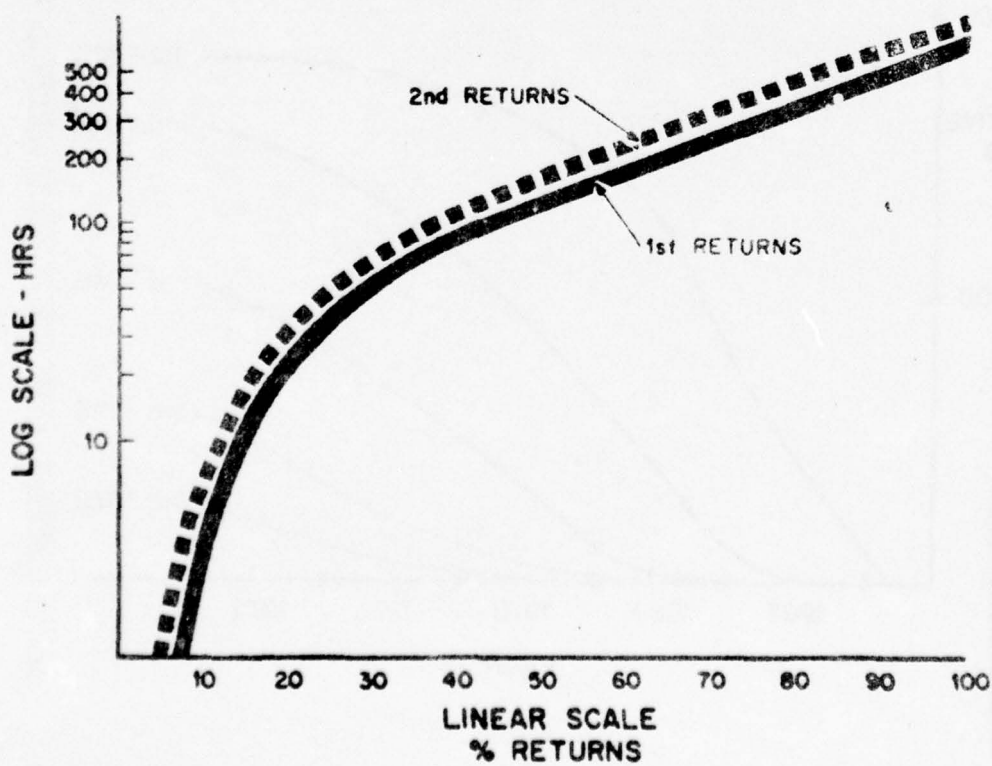
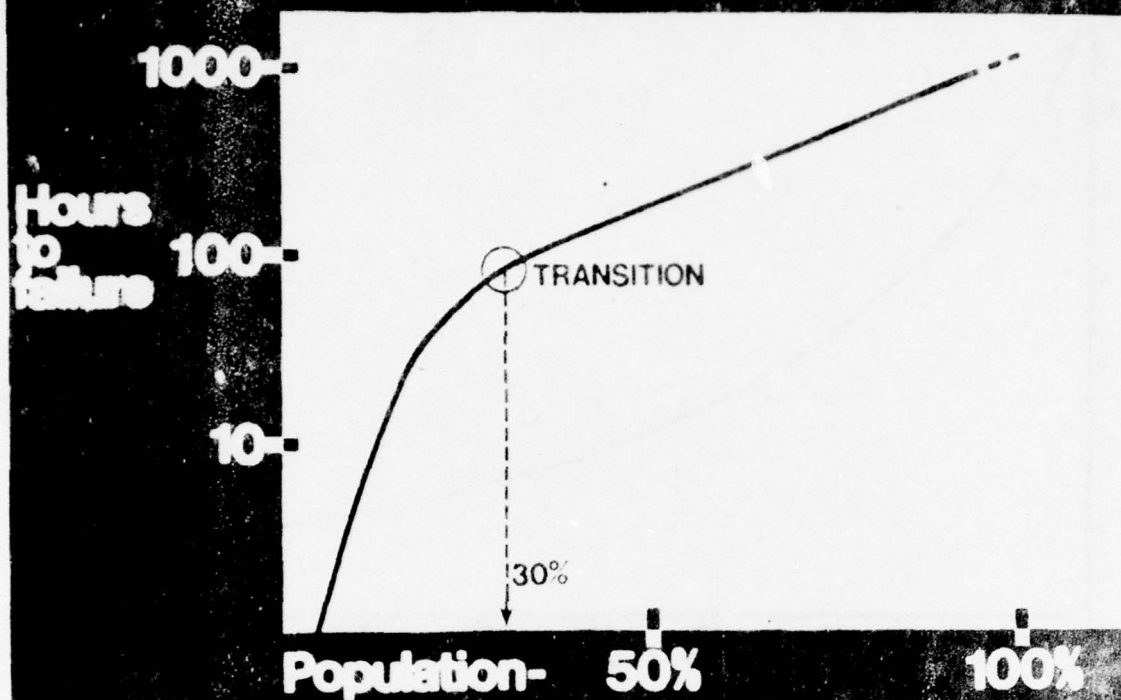
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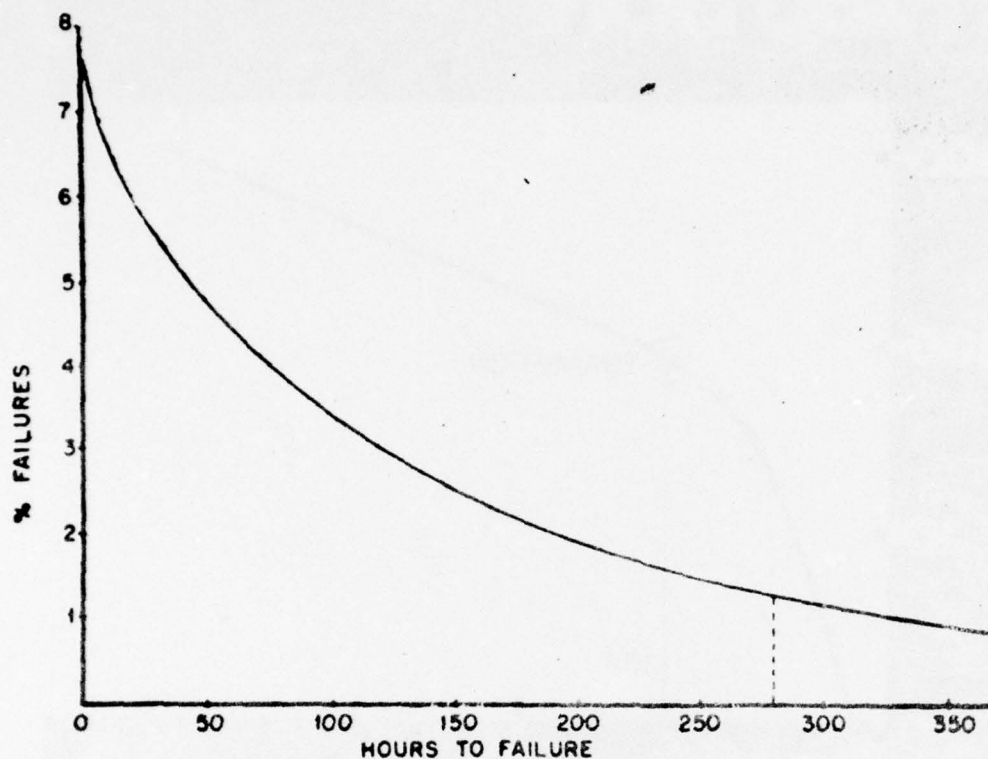


TURN AROUND TIME.. segmented

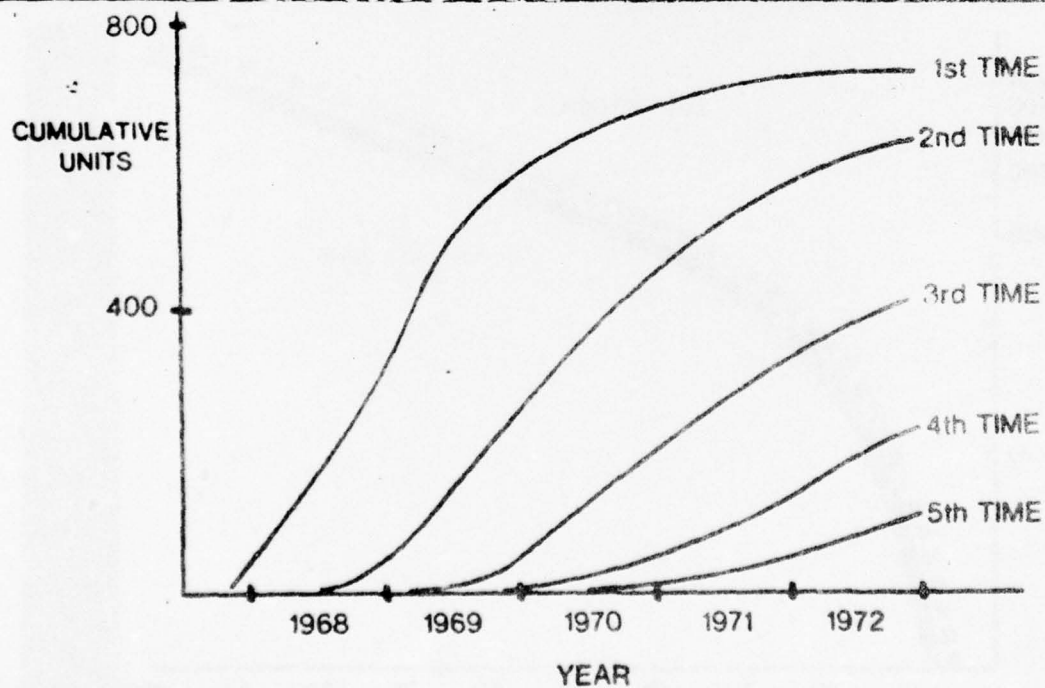


DISTRIBUTION





RETURNS EACH TURN AROUND





SUMMARY

ANALYSIS CAN :

► DEVELOP COST/UTILITY

★ ALTERNATIVES

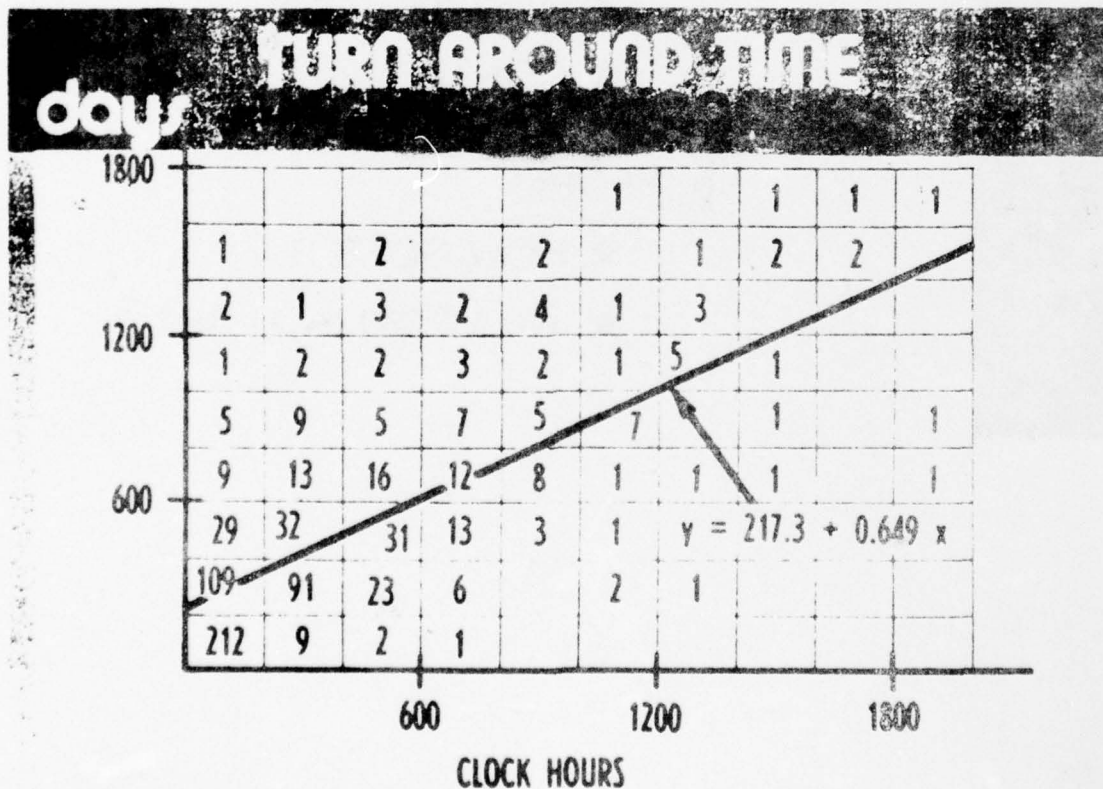
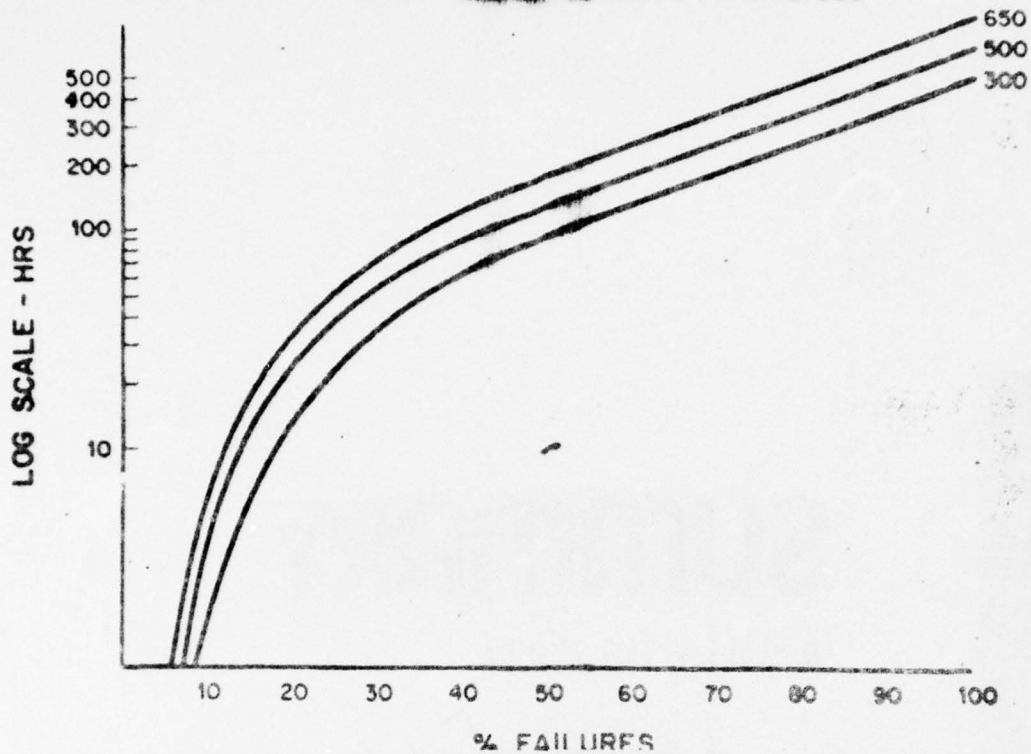
★ CONTRACTING

► INFORM

★ HOW GOES IT ?

★ WHAT DID YOU GET ?

PROOF OF EXPONENTIAL



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ARMY UTILIZATION OF LIFE
CYCLE COSTING

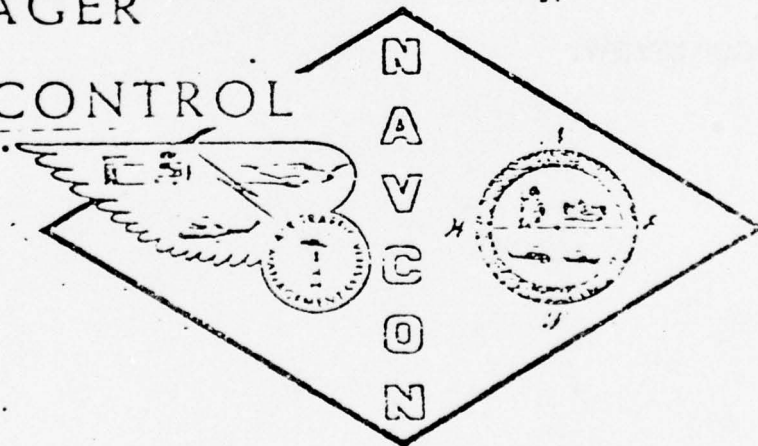
THOMAS E. McGUIRE

AUTOVON 992-4476

A/C 201 - 532-4476

U.S. ARMY MATERIEL COMMAND

PROJECT MANAGER
NAVIGATION/CONTROL
SYSTEMS



Fort Monmouth, New Jersey 07703

VU-GRAPH '1 - NAVCON

GOOD MORNING GENTLEMEN. - I AM TOM MCGUIRE, A COST ANALYST FROM THE ARMY'S PROJECT MANAGER FOR NAVIGATION AND CONTROL. I APPRECIATE THIS OPPORTUNITY TO DISCUSS LIFE CYCLE COST WITH YOU. MY PAPER TODAY WILL DEAL WITH OUR UTILIZATION OF LIFE CYCLE COSTING AND MOST IMPORTANT - HOW WE ARE USING THIS TECHNIQUE WITH OUR CONTRACTORS TO REDUCE THE COST OF OUR NAVIGATION EQUIPMENT.

WE BELIEVE THE ADDITION OF LIFE CYCLE COSTING TO THE DESIGN TO COST PROGRAM WILL HAVE A VERY POSITIVE EFFECT ON OUR EFFORTS TO GET BETTER EQUIPMENT AT A LOWER COST - A TRUE COST EFFECTIVE APPROACH TO SATISFYING THE ARMY REQUIREMENT FOR AFFORDABLE NAVIGATION EQUIPMENT.

MY TALK TODAY WILL DEAL WITH LIFE CYCLE COSTING, AND OUR REQUIREMENT FOR CONTRACTORS TO DO COST OF OWNERSHIP STUDIES. I ALSO HAVE COPIES OF OUR LIFE CYCLE COST WORK STATEMENTS AND EXAMPLES OF THE GEMM FOR YOUR REVIEW.



ARMY UTILIZATION OF LIFE CYCLE COST

VU-GRAPH 12

I HAVE LISTED OUR BASIC THRUST AND ITS EFFECT ON LIFE CYCLE COST - NO DOUBT YOU ARE FAMILIAR WITH SUCH A GROUP. MOST IMPORTANT - WE ARE TRYING TO INCORPORATE LIFE CYCLE COST INTO OUR ENGINEERING DEVELOPMENT EFFORT, TO ALLOW COST AND DESIGN TO MIX SO WE HAVE A WORKABLE SYSTEM AT A PRICE WE CAN AFFORD.

FIRST - WE ARE TRYING TO MINIMIZE LIFE CYCLE COST. I SAY MINIMIZE BECAUSE WE HAVE FIXED CRITERIA BELOW WHICH COST SAVINGS ARE NOT WORTH ACHIEVING. FOR EXAMPLE, WE WANT GOOD MEAN TIME TO REPAIR AND MEAN TIME BETWEEN FAILURE (1000 HOURS) BECAUSE WE REQUIRE SYSTEMS THAT ARE RELIABLE AND AVAILABLE. IN ADDITION, WE HAVE MINIMUM STOCKAGE CONFIDENCE LEVELS TO REDUCE MEAN DOWN TIME. IT MIGHT EVEN REDUCE LIFE CYCLE COST TO REDUCE THESE AVAILABILITY FACTORS - NEVERTHELESS, SYSTEM EFFECTIVENESS WOULD SUFFER - AND PLACING PRICE VALUE ON THE MARGINAL UTILITY OF AVAILABILITY IS VERY SUBJECTIVE.

WE STILL LEAVE OUR CONTRACTORS ENOUGH ROOM TO DO COST EFFECTIVENESS TRADE-OFF AND HOPEFULLY, REDUCE LIFE CYCLE COST OR INCREASE EFFECTIVENESS. I'LL HAVE A FEW EXAMPLES LATER.

I LIST A BASIC THRUST OF OUR COSTING TO BE LESS COMPLEX EQUIPMENT AND DECREASED USE OF NON-STANDARD PARTS. WE BELIEVE THIS MAKES OUR EQUIPMENT MORE RELIABLE THROUGH REDUCED PARTS COUNT AND MORE

PROCURABLE/SUPPORTABLE, BECAUSE WE USE STANDARD PARTS. AGAIN, I'LL
SHOW AN EXAMPLE OF COST REDUCTION FROM THE NON-STANDARD PARTS
PROBLEM.



BASIC THRUST OF LIFE CYCLE COSTING

1. MINIMIZE LIFE CYCLE COST
2. MEET DESIGN TO COST OBJECTIVES
3. STIMULATE COST EFFECTIVE TRADE OFFS
4. REDUCE SYSTEM COMPLEXITY
5. REDUCE NON-STANDARD PARTS

INCORPORATE LCC INTO SYSTEM DESIGN DURING DEVELOPMENT

VU-GRAPH #3

GIVEN THE THRUST OF WHAT THE ARMY WANTS TO DO - THE QUESTION BECOMES ONE OF DEFINING THE KEY VARIABLES IN THE LIFE CYCLE COST EQUATION - AND HERE I DISPLAY A FEW.

a. FIRST, WE BELIEVE THE UNIT PRODUCTION COST WILL CONTRIBUTE A MINIMUM OF 50% - 60% OF OUR LIFE CYCLE COST FOR HIGH RELIABLE SYSTEMS. THAT % SOUNDS VERY HIGH WHEN COMPARED TO THE OLDER LOW MTBF EQUIPMENT - BUT THAT'S WHAT OUR COST ANALYSIS IS SHOWING. THEREFORE - THE UNIT PRODUCTION COST SHOULD BE TIGHT ENOUGH TO CHALLENGE OUR CONTRACTORS. EVERY DOLLAR SAVED ON THE HARDWARE COST IS RETURNED DURING THE OPERATING YEARS AS A RESULT OF LOWER COST AND SMALLER QUANTITY SPARE PARTS FLOAT. RELIABILITY IS AFFECTED BY THE TWIN MEAN TIMES - BETWEEN FAILURE AND TO REPAIR. OBVIOUSLY MTBF MEANS FAILURES, AND MTTR IMPACTS ON TIME TO REPAIR. AGAIN - THESE VALUES APPROACH SOME ASYMPTOTICAL VALUE BEYOND WHICH COST SAVINGS ARE NOT COST EFFECTIVE.

NON-STANDARD PARTS COST ARE INCLUDED IN MOST LIFE CYCLE COST EQUATIONS AND THE ARMY ELECTRONICS COMMAND IS NO DIFFERENT. IF THE COST TO ENTER NEW ITEMS INTO THE INVENTORY ARE VARIABLE COSTS - AND WE ASSUME THEY ARE - REDUCING NON-STANDARD PARTS SAVES MONEY.

I HAVE INCLUDED BOTH THE COST AND QUANTITY OF TEST EQUIPMENT, OUR EXPERIENCE ON A RECENT PROGRAM INDICATED THAT TEST

EQUIPMENT OR AGE CAN BE LESS EXPENSIVE , PURCHASED IN SMALLER QUANTITIES, AND STILL SATISFY OUR MAINTENANCE REQUIREMENTS.

OUR LAST COST DRIVE IS THE ARMY MAINTENANCE POLICY. NOW CONTRACTORS DO NOT DETERMINE THIS POLICY - BUT THEY CAN MAKE A RECOMMENDATION. THEY RECOMMEND WHERE THE EQUIPMENT IS REPAIRED (AT WHAT LEVEL) AND WHAT TYPE TEST EQUIPMENT IS REQUIRED TO COMPLETE THIS REPAIR. (SUPPORT LEVEL IS AN INPUT OF THE GEMM)



LIFE CYCLE COST DRIVERS

1. DESIGN TO UNIT PRODUCTION COST
2. MEAN TIME TO REPAIR
3. MEAN TIME BETWEEN FAILURES
4. NUMBER OF NON-STANDARD PARTS
5. COST AND QUANTITY OF TEST EQUIPMENT
6. ARMY MAINTENANCE POLICY

VU-GRAPH #4

TO HELP OUR CONTRACTORS DO ALL THIS GOOD ANALYSIS - WE PROVIDE A GENERALIZED ELECTRONICS MAINTENANCE MODEL (GEMM). THIS IS BASICALLY A TECHNIQUE TO RECOMMEND AN ARMY SUPPORT METHOD. WE ADD BOTH THE INVESTMENT AND RD - PLUS A FEW EXTRA FACTORS TO ARRIVE AT A VERY RIGOROUS AND FAST LIFE CYCLE COST MODEL. THIS MODEL ALSO PROVIDES MEASURES OF EFFECTIVENESS FOR EVALUATING EACH COST TRADE-OFF. THE ATTACHED LIST PROVIDES A COMPENDIUM OF GOVERNMENT SUPPLIED INPUT DATA.

MILITARY PAY RATES AND TRAINING COSTS ARE SUPPLIED BY PAY GRADE AND MILITARY OCCUPATIONAL SPECIALTY (MOS). WE ALSO PROVIDE INFLATION RATES - DISCOUNT RATES AND OTHER LOGISTICS FACTORS.



GOVERNMENT SUPPLIES

GEMM MODEL

MILITARY PAY RATE

MILITARY TURNOVER RATES

INFLATION FACTORS

DISCOUNT RATES

DEPLOYMENT QUANTITIES

TRANSPORTATION DISTANCES

REQUISITION TIME

MANPOWER TYPES

VU-GRAPH '5

CONTRACTOR DATA INCLUDES VERY DETAILED RELIABILITY AND
MAINTAINABILITY DATA DOWN TO THE MODULE AND PIECE PART LEVEL.

THIS INFORMATION - PLUS MODULE COST AND TEST EQUIPMENT
REQUIREMENTS - ARE COMBINED WITH THE GOVERNMENT DATA TO GENERATE
A GEMM RUN. PLEASE NOTE THE LIFE CYCLE COST DISPLAYED, A FICTITIOUS -
BUT TYPICAL - PRINTOUT. ALSO - NOTE THE EFFECTIVENESS FACTORS AS
DISPLAYED BELOW.

VU-GRAPH #6

A SERIES OF SENSITIVITY RUNS ARE ILLUSTRATED ON THIS CHART. IN THIS CASE, WE HAVE MADE CHANGES IN THE STOCKAGE CONFIDENCE LEVEL - I.E. WHAT IS THE PROBABILITY THAT A REPAIR PART IS AVAILABLE WHEN REQUIRED? STOCKAGE CONFIDENCE FIRST IMPACTS ON MEAN DOWN TIME - THE HIGHER THE STOCKAGE % - THE LOWER THE MEAN DOWN TIME. NEXT THESE TWO NUMBERS IMPACT LIFE CYCLE COST AND AVAILABILITY. AGAIN, THE MORE SPARE PARTS THE HIGHER THE LCC - LOWER MDT - HIGHER AVAILABILITY AND HENCE, HIGH COST EFFECTIVENESS.



OPERATIONAL AVAILABILITY, SENSITIVITY RUN

<u>Life Cycle Cost</u>	<u>Availability</u>	<u>Cost Effectiveness</u>	<u>MDT</u>	<u>Stockage Level</u>
\$60.0M	.97	1.6	64	90%
\$70.0M	.98	1.4	25	95%
\$50.0M	.95	1.9	72	80%

$$\text{Effectiveness} = \frac{.97}{\$60.0M} = 1.6$$

VU-GRAPH #7

I AM SURE YOU ALL UNDERSTAND THAT SUPPORT COST WHICH CONTRIBUTES HALF OUR LIFE CYCLE COST IS THE MOST DIFFICULT AREA TO MEASURE AND EVALUATE. THE LIST I DISPLAY INCLUDES:

TEST EQUIPMENT - HOW MUCH - HOW COMPLEX?

SPARE PARTS A FUNCTION OF MTBF AND MEAN DOWN TIME.

PERSONNEL: COST FOR MAINTENANCE PEOPLE ARE TRUNCATED - THAT IS, IF YOU NEED A FRACTION OF A MAN AT ANY LOCATION, THE COMPUTER ROUNDS UP TO THE NEXT WHOLE NUMBER.

TRANSPORTATION COST: A FUNCTION OF MTBF, SPARE LEVEL, DISTANCE BETWEEN MAINTENANCE CITES, ARMY MAINTENANCE POLICY AND TRANSPORTATION TIME.

INVENTORY COST: INCLUDES THE COST TO HOLD AND MAINTAIN SPARE PARTS.

PUBLICATION: THIS ITEM INCLUDES ALL DATA, DRAWINGS, MANUALS, TEST REPORTS, QUALITY CONTROL ANALYSES, ETC.

WE HAVE A PROBLEM IN CLOSING THE LOOP ON SUPPORT COST ESTIMATES BECAUSE MOST OF THE ITEMS ARE NEVER REPORTED BACK. THEREFORE - WE HAVE AN ESTIMATE THAT IS NEVER REALLY CROSS-CHECKED. IN ADDITION - WE MAY

GET INTO THE FIXED COST VS. VARIABLE COST PROBLEM FOR MAINTENANCE. FOR
EXAMPLE - WHAT IS THE COST OF AN OPERATION UNIT IF WE HAVE 1000 HOURS OF
FLYING TIME PER MONTH? - WHAT IS THE COST FOR 10 HOURS PER MONTH? IN
THE LONG RUN, THE PRICE WOULD CHANGE - IN THE SHORT RUN, THE COST
OF EACH FLYING HOUR WOULD GO UP.



LIFE CYCLE SUPPORT COST

- A. TEST EQUIPMENT
- B. SPARE AND REPAIR PARTS
- C. PERSONNEL
- D. TRANSPORTATION
- E. TRAINING
- F. INVENTORY MANAGEMENT
- G. PUBLICATIONS

VU-GRAPH #8

I WANT TO GO OVER ONE FACET OF THE SUPPORT COST EQUATION. WE CALL THIS ITEM INVENTORY COST. FIRST - WE CHARGE A PENALTY FOR THE INTRODUCTION OF NEW ITEMS INTO THE INVENTORY - THE VARIABLE COST FOR THE ARMY TO SUPPORT THIS NEW NON-STANDARD PART. IF WE ASSUME THE UNIT, AN INERTIAL NAVIGATOR WILL COST OVER \$24,999 - IT WILL COST \$680 TO ACQUIRE A FEDERAL STOCK NUMBER FOR EACH NON-STANDARD PART IN THE ITEM. IN ADDITION, A RECURRING COST FOR EACH YEAR IN THE INVENTORY IS ADDED FOR THE TEN YEAR LIFE.

VU-GRAPH 19

FOR EXAMPLE - GIVEN THE ITEM HAS 100 NON-STANDARD PARTS.
WE MUST ACQUIRE SPECIFICATION CONTROL DRAWINGS, ESTABLISH SECOND SOURCES
AND ASSIGN THE FSN. OBVIOUSLY, REPROCUREMENT AND SUPPORT OF FIELDED
HARDWARE IS IMPORTANT IN THIS COST. FROM OUR EXAMPLE - THE TOTAL COST
TO ADD THE 100 ITEMS IS NEARLY \$2500 A PART, OVER THE 10 YEAR LIFE CYCLE.
IN THE CASE OF A \$25,000 EQUIPMENT - REDUCING NON-STANDARD PARTS BY
10% WILL PAY FOR 10 ADDITIONAL SETS.



ITEM INVENTORY COST

100 NON-STANDARD PARTS FOR SUPER HIGH DOLLAR VALUE

	<u>TOTAL</u>
INTRODUCTION	
100 ITEMS X \$680	\$68,000
1ST YEAR COST	
100 ITEMS X \$1070	\$107,000
9-YEAR RECURRING COST	
100 X \$720	\$72,000

10 YEAR COST, INVENTORY HOLDING	\$247,000

VU-GRAPH #10

A SECOND CHANGE INVOLVED WITH INVENTORY DOLLARS IS THE COST TO HOLD - OR 33% PER YEAR. WE ASSUME THAT INFLATION/INVESTMENT OPPORTUNITIES AT THE RATE OF 10% ARE LOST EACH YEAR WE "TIE UP" OUR MONEY IN STOCKS/PARTS TO SUPPORT HARDWARE. WE ALSO ASSUME THAT 20% OF THE PIECE PARTS WILL NEVER BE USED BECAUSE THEY BECOME OBSOLETE DUE TO ENGINEERING CHANGES, NEW TECHNOLOGY, ETC. OTHER COSTS - INCLUDING PILFERAGE, STOCKAGE, AND DAMAGES - CAN ADD 3% TO THE LIFE CYCLE COST.

THEREFORE - IMPROVEMENT IN RELIABILITY - THAT ELUSIVE CONCEPT WE ARE SEEKING DURING DEVELOPMENT - IS REWARDED IN LOWER LIFE CYCLE COST AND HOPEFULLY, MAY BE A KEY DISCRIMINATOR IN AWARDING PRODUCTION CONTRACTS.- THIS IS VERY IMPORTANT.



COST TO HOLD INVENTORY

INVESTMENT COST	10%
OBSOLESCENCE LOSSES	20%
OTHER LOSSES	2%
STORAGE COSTS	1%
TOTAL	33%

VU-GRAPH #II

DURING THE DEVELOPMENT PORTION OF A CONTRACT, WE EXPECT CONTRACTORS TO DO THE TRADING-OFF AND SENSITIVITY ANALYSIS ON OUR HARDWARE AND CONSIDER THE IMPACT ON EACH ITEM BELOW.

WHEN A CHANGE IS MADE TO THE BASIC LINE REPLACEABLE UNIT DURING DEVELOPMENT, THE RIPPLE IS FELT IN EACH AREA I HAVE LISTED. THE CHANGE MAY BE LARGE OR SMALL - BUT REGARDLESS, THE USE OF THE GEMM GIVES THE CONTRACTOR A ON-TIME UPDATE.



TRADE-OFF ANALYSIS

COST OF OWNERSHIP

COSTS INCLUDE ALL:

HARDWARE UNITS

DATA

SPARE PARTS

REPAIR PARTS

TRAINING

TOOLING

SPECIAL TEST EQUIPMENT

OPERATING COST

VU-GRAPH #12

THIS COST EFFECTIVENESS/SENSITIVITY CHART DEPICTS THE BASIC CONCEPT OF INCREASING EFFECTIVENESS OVER A SIGNIFICANT RANGE WITH VERY SMALL INCREASES IN TOTAL COST. THE KEY FACTORS ARE SUPPORT/ MAINTENANCE DATA. FOR EXAMPLE - CHANGES IN PRODUCTION OR NON-RECURRING COST WOULD MOST LIKELY CHANGE THE TOTAL LIFE CYCLE COST. HOWEVER - CHANGES IN ANY SUPPORT COST WILL IMPACT ON BOTH COST AND EFFECTIVENESS. THE ONE KEY IN THE EFFECTIVENESS RATIO IS OPERATIONAL AVAILABILITY.

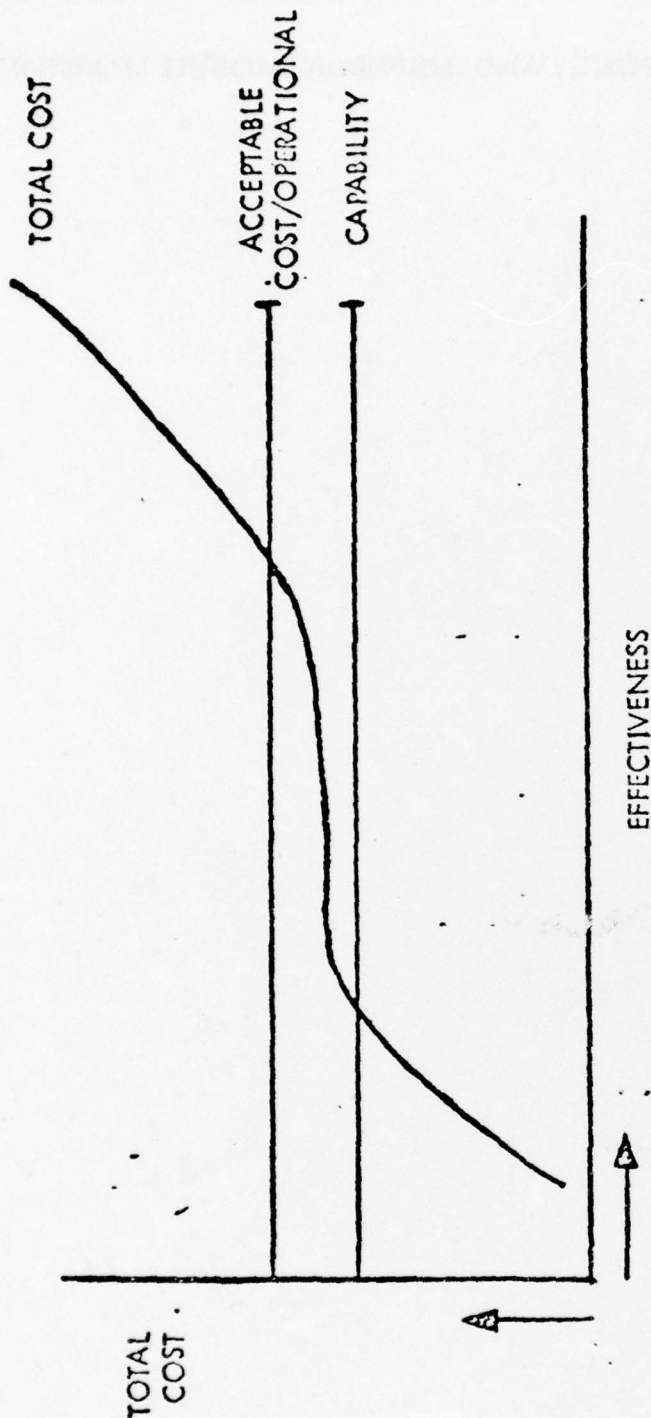
OPERATIONAL AVAILABILITY IS, IN TURN, A OUTPUT OF MEAN DOWN TIME - WHICH INCLUDES:

- A. PROBABILITY OF EQUIPMENT, COMPONENT, MODULE OR SPARE PART IS AVAILABLE.
- B. MEAN CHECKOUT/REPAIR TIME FOR HARDWARE, EQUIPMENT, LRU, MODULE.
- C. TRANSPORTATION FOR ANY OR ALL THE ABOVE - TO AND FROM REPAIR.
- D. WAITING TIME FOR ALL ACTIONS ABOVE, PLUS REQUISITION TIME FOR PARTS.

SIGNIFICANT PORTIONS OF THIS MEAN DOWN TIME ARE GOVERNMENT INPUTS AS I DISCUSSED BEFORE - OTHERS ARE CONTRACTOR SELECTION FOR THE

RECOMMENDED MAINTENANCE POLICY AND INDIVIDUAL MODULE RELIABILITY
VALUES.

COST EFFECTIVENESS SENSITIVITY



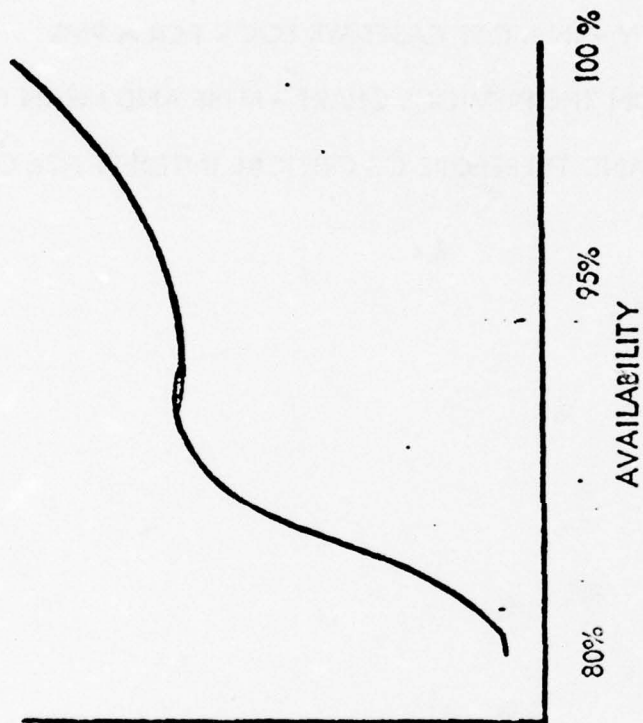
$$\text{COST EFFECTIVENESS} = \frac{\text{OPERATIONAL AVAILABILITY}}{\text{LIFE CYCLE COST}}$$

$$\text{OPERATIONAL AVAILABILITY} = \frac{\text{MTBF}}{\text{MTBF} + \text{MDT}}$$

VU-GRAPH /13

OPERATIONAL AVAILABILITY TAKES THE SAME GENERAL FORM AS THE EFFECTIVENESS RATIO. LET ME ADD THAT WE DETERMINE THE ABSOLUTE MINIMUM WE WILL ACCEPT FOR AVAILABILITY - IN MOST CASES WE LOOK FOR A 95% AVAILABILITY. AS ILLUSTRATED ON THE PREVIOUS CHART - MTBF AND MEAN DOWN TIME ARE THE KEY COST DRIVERS AND THEREFORE OF CRITICAL INTEREST FOR COST EFFECTIVE CHANGES.

OPERATIONAL AVAILABILITY



LIFE CYCLE COST

$$\text{AVAILABILITY} = \frac{\text{MTBF}}{\text{MTBF} + \text{MDT}}$$

MTBF = MEAN TIME BETWEEN FAILURES

MDT = MEAN DOWN TIME

VU-GRAPH #14

SUPPORT COST - THIS CHART - WHICH I HAVE REPRODUCED FROM THE DEFENSE MANAGEMENT JOURNAL - ILLUSTRATES A PHENOMENON WE HAVE OBSERVED WITH THE GEMM MODEL - THAT IS, AS EXTRA - OR MARGINAL - CHANGES ARE ADDED TO ANY ONE FACTOR - IN THIS CASE, MEAN TIME BETWEEN MAINTENANCE ACTIONS - THE NUMBER OF MAINTENANCE ACTIONS REDUCES AND THE LIFE CYCLE COST REDUCES - BUT AT AN EVER DECREASING RATE. YOU MAY RECOGNIZE THIS CURVE AS A BASIC ECONOMIC THEOREM THE LAW OF DIMINISHING RETURNS - OR MORE PRECISE - DEMINISHING MARGINAL PHYSICAL PRODUCT.

<u>TIME BETWEEN MAINTENANCE</u>	<u>LCC</u>	<u>COST SAVED (MPP)</u>
100	\$60M	\$ -45 M
400	15M	
600	10M	\$ -5 M
800	8M	\$ -2 M

WE CAN EXPLAIN SOME OF THESE FACTORS. ONE CANNOT HAVE LESS THAN 1 MAINTENANCE MAN - NOR 1/2 A PRICE OF TEST EQUIPMENT. AS MTBF GOES UP, CAPITAL ASSETS WOULD BE USED LESS - THEREFORE, VARIOUS FACTORS ARE BEING USED LESS EFFECTIVELY.

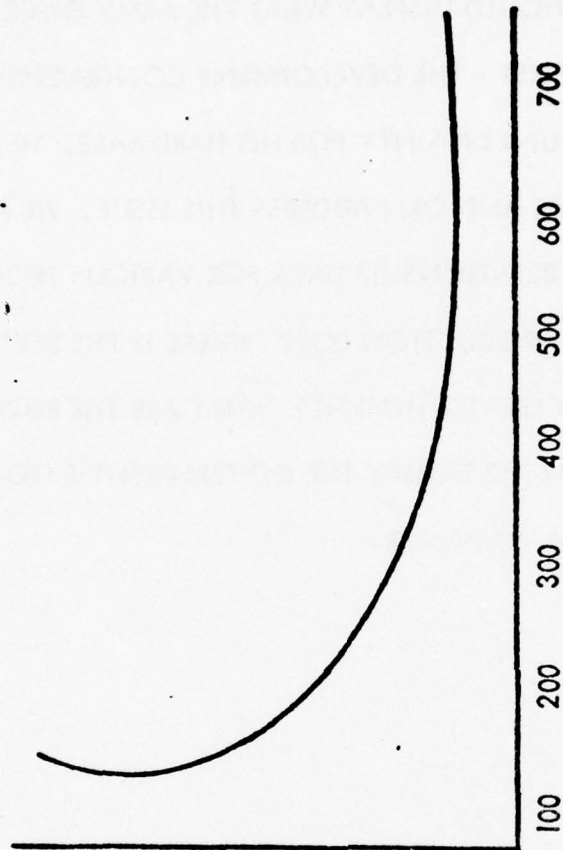
ONE PROBLEM THAT BOTHERS ME IS - ARE THE FUNDAMENTAL EQUATIONS CORRECT, OR WERE THEY GENERATED AT A TIME WHEN MOST AVIONICS SYSTEM

HAD RELATIVELY LOW MTBF. THEREFORE - RELIABILITY DATA FOR MTBF IN EXCESS OF 1000 HOURS WAS ASSUMED TO BE AT INFINITY.



SUPPORT COST VS. MTBM

LIFE CYCLE
SUPPORT COST



MEANTIME BETWEEN MAINTENANCE ACTIONS

SOURCE: DEFENSE MANAGEMENT JOURNAL, JULY 73

VU-GRAPH #15

MY LAST TWO CHARTS SHOULD DISPLAY WHAT THE ARMY EXPECTS TO GET FROM LIFE CYCLE COSTING. FIRST - THE DEVELOPMENT CONTRACTOR HAS THE BEST DATA TO EVALUATE RISK AND UNCERTAINTY FOR HIS HARDWARE. HE HAS THE MOST SUPERIOR COST DATA BASE AND CAN ADDRESS THIS ISSUE. WE ALSO ARE SEEKING THE COST QUANTITY RELATIONSHIP DATA FOR VARIOUS PRODUCTS SIZES - WHAT IS THE ECONOMICAL PRODUCTION LOT? WHERE IS THE BREAK-EVEN POINT FOR AUTOMATIC TOOL AND TEST EQUIPMENT? WHAT ARE THE REQUIREMENTS IN TERMS OF DESIGN AND MATERIAL TO SATISFY THE GOVERNMENT'S GOALS? - BE THEY PRICE, RELIABILITY OR PERFORMANCE.



CONTRACTOR CONDUCTS:

EVALUATION OF RISK AND UNCERTAINTY.

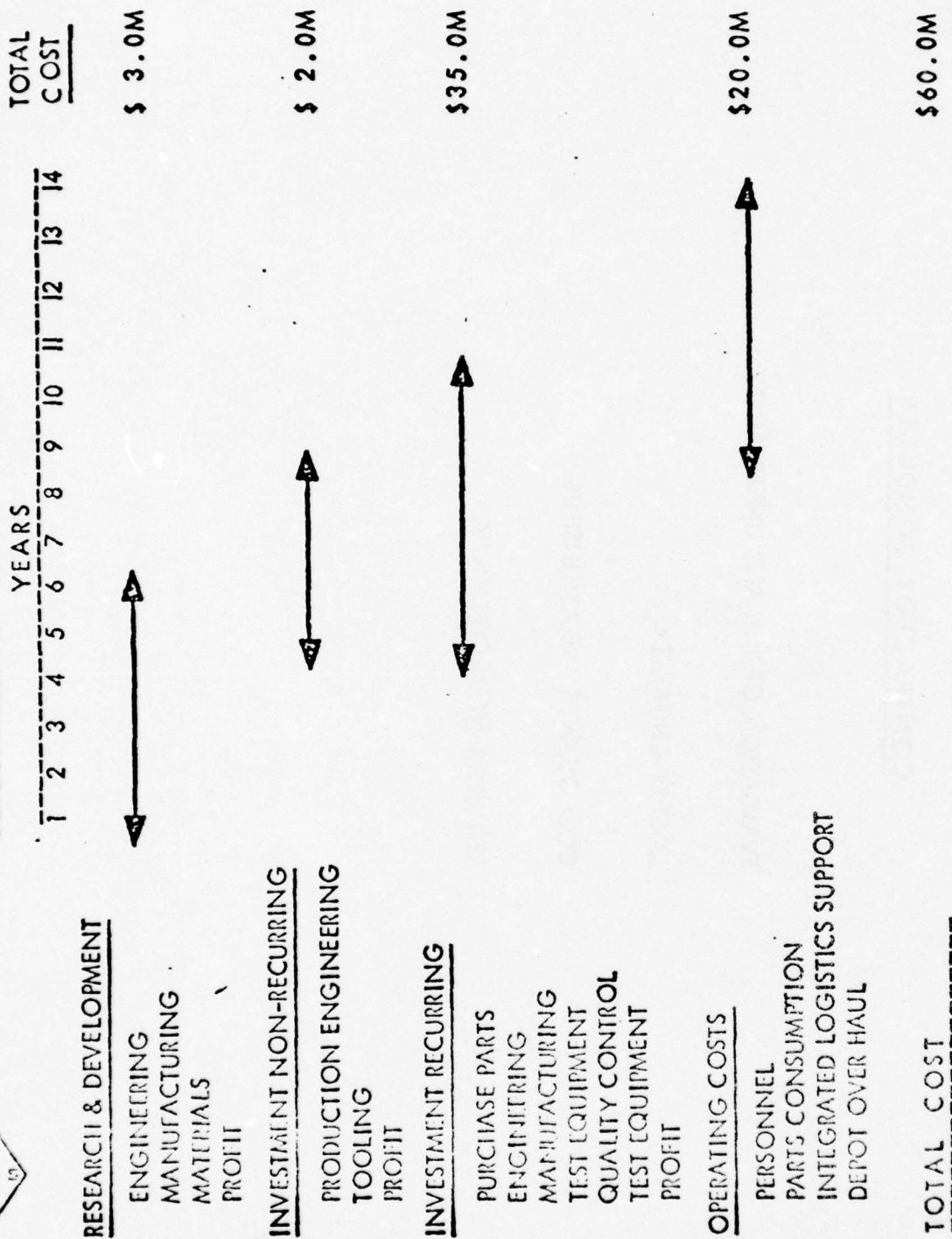
COST UNCERTAINTY.

COST QUANTITY RELATIONSHIPS.

REQUIREMENT UNCERTAINTY.



LIFE CYCLE COST (TIME PHASED)



VU-GRAPH #16

IN CONCLUSION, WHEN THE CONTRACTOR HAS COMPLETED THE LIFE CYCLE COST ANALYSIS, HE HAS THE DATA TO GENERATE THIS TIME PHASED CHART. IT SHOULD BE COMPLETED IN CONSTANT DOLLARS/OR INFLATED DOLLARS TO PROVIDE A SNAPSHOT OF WHERE THE ITEM IS. MOST OF YOU UNDERSTAND THE GOVERNMENT HAS COMPLETED THIS TASK - EVEN BEFORE THE RD CONTRACT IS SIGNED. THEREFORE - WE HAVE SOME CHECK ON THE BELIEVEABILITY OF CONTRACTOR DATA. IN ADDITION, WE ARE DEVELOPING A BETTER DATA BASE . BUT MOST IMPORTANT - WE BELIEVE THE USE OF THE LIFE CYCLE COSTING WILL REDUCE THE TOTAL COST FOR OUR EQUIPMENTS AND IMPROVE THE RELIABILITY. WE THINK THE USE OF THIS TOOL WILL ALLOW CONTRACTORS TO DEVELOP EQUIPMENT WITH FAR MORE KNOWLEDGE AND INSIGHT.

BERNARD DeVOTA ONCE SAID: BETWEEN THE AMATEUR AND THE PROFESSIONAL THERE IS A DIFFERENCE NOT ONLY IN DEGREE - BUT IN KIND. WE - NAVCON - AND OUR CONTRACTORS, ARE GOING TO BE PROFESSIONALS.

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F-16
AIR COMBAT FIGHTER
LIFE CYCLE COST
PROGRAM

by

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F-16 AIR COMBAT FIGHTER LIFE CYCLE COST PROGRAM





LIFE CYCLE COST APPROACH



- EVALUATE TOTAL COST TO GOVERNMENT DURING SOURCE SELECTION
- ESTABLISH MEANS TO INCENTIVIZE CONTRACTOR FOR DTC/LCC DURING FULL SCALE DEVELOPMENT
- INCORPORATE PROVISIONS REFLECTING CONTRACTOR INCENTIVES/COMMITMENTS ON SUPPORTABILITY



COMPARATIVE EVALUATION DURING SOURCE SELECTION

- INDEPENDENT COST ANALYSIS
 - PARAMETRIC ESTIMATES FOR R&D AND ACQUISITION
 - AIR FORCE PACE MODEL FOR OPERATING & SUPPORT COST
- LOGISTICS SUPPORTABILITY COST IMPACT
 - USING AFLC LOGISTICS SUPPORT COST MODEL
 - ESTIMATES SCALED FROM EXISTING EQUIPMENT
 - DESIGN SUPPORTABILITY SUMMARY



CONTRACTOR INCENTIVES DURING FULL SCALE DEVELOPMENT



- DTC/LCC TRADE STUDIES
 - AFFECTING DESIGN COST REDUCTION
 - AFFECTING SUPPORTABILITY
- AWARDS FEE OF \$3.2 MILLION



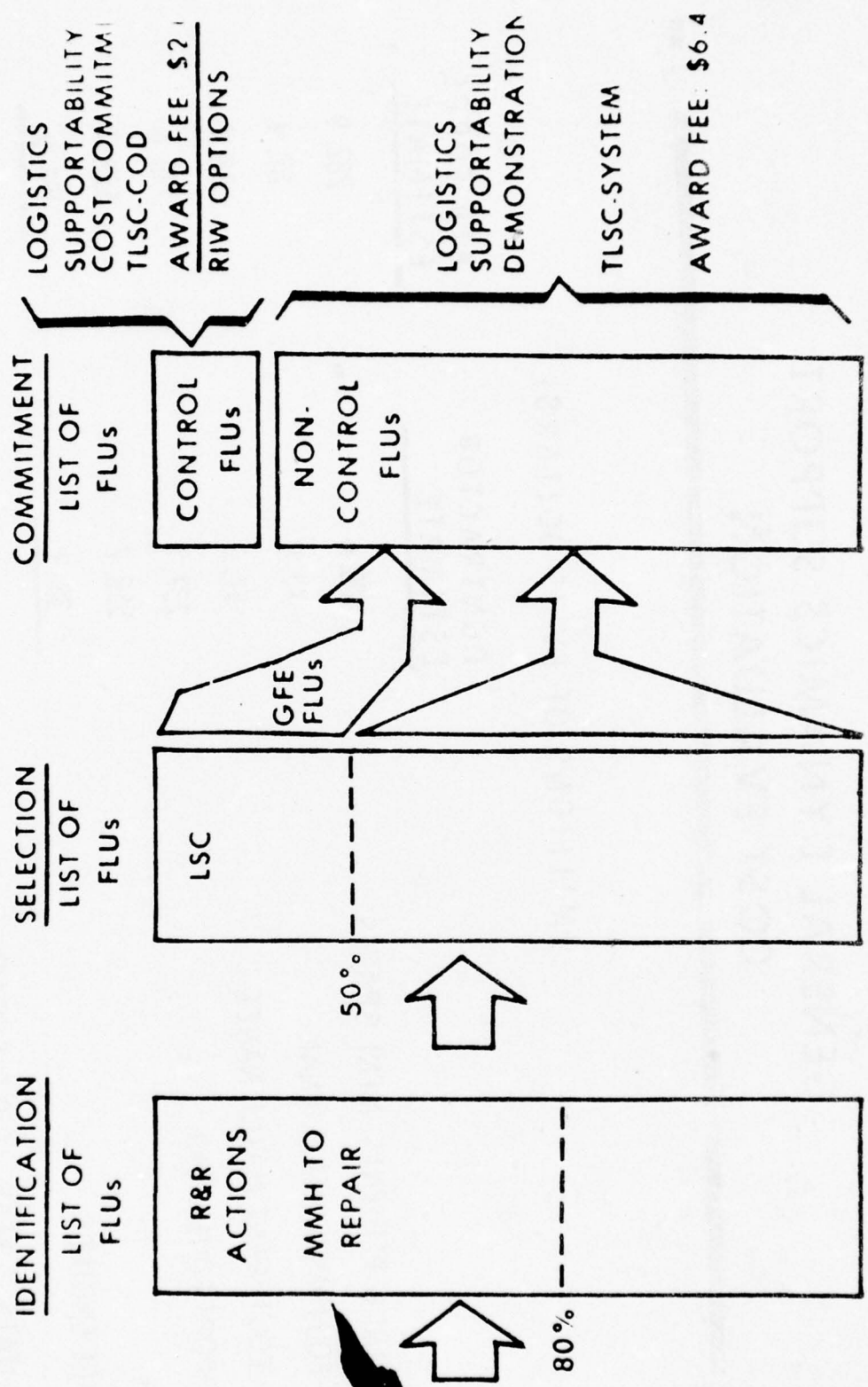
OBJECTIVES OF PROCUREMENT APPLICATIONS



- CONTRACTOR COMMITMENTS ON SUPPORTABILITY
- ECONOMIC INCENTIVE WHICH MOTIVATES CONTRACTOR AND VENDORS TOWARD ACHIEVING SUPPORTABILITY REQUIREMENTS
- SUPPORTABILITY COMMITMENTS AS A MAJOR CONSIDERATION IN SOURCE SELECTION
 - OBJECTIVITY AND REALISM IN CONTRACTOR PROPOSALS
 - CREDIBLE ASSESSMENTS OF SUPPORTABILITY RISKS
- VEHICLE FOR CONTROL OF DESIGN FOR REDUCED O&S COSTS
- MANAGEMENT FOCUS ON HIGH LOGISTICS RESOURCE CONSUMERS



ESTABLISHMENT OF SUPPORT COST CONTROL STRUCTURE F-16



GENERAL DYNAMICS SUPPORT COST EVALUATION

(MILLIONS OF FY 75 DOLLARS)

	<u>CONTRACTOR ESTIMATE</u>	<u>AIR FORCE ESTIMATE</u>
INITIAL & REPLENISHMENT SPARES	108.6	282.9
ON-EQUIPMENT MAINTENANCE	73.9	87.9
OFF EQUIPMENT MAINTENANCE	57.5	88.2
SUPPORT EQUIPMENT	237.1	218.6
SPARE ENGINES	558.7	558.7
	<u>38.9</u>	<u>153.0</u>
TOTALS 15 YEAR 600 AIRCRAFT	1,074.6	1,389.2



SUPPORT COST CONTROL



- SELECTED GROUP OF "HIGHBURNER" COMPONENTS
 - CONTRIBUTE NO LESS THAN 50% OF POTENTIAL SUPPORT COSTS
 - CFE ITEMS ONLY
 - FUTURE COMMITMENT INCLUDES RADAR ITEMS
- COVERED UNDER LOGISTICS SUPPORTABILITY COST COMMITMENT PROVISION (COD)
- COVERED UNDER OPTION FOR
 - RIW
 - RIW WITH MTBF GUARANTEE



RIW / COD COVERAGE GENERAL DYNAMICS (MILLIONS OF FY75 DOLLARS)



COMPONENT *	15 YEAR TLSC	RIW PRICE	MTBF GUARANTEE	COD ** PRICE
1. INERTIAL NAVIGATION UNIT	\$ 5.6	\$ 1.9	\$ 1.4	\$ 1.9
2. FLIGHT CONTROL COMPUTER	3.3	3.2	2.3	1.2
3. RADAR E/O DISPLAY	3.3	1.5	1.0	0.7
4. HUD DISPLAY	2.9	1.5	1.1	2.3
5. DIGITAL SCAN CONVERTER	2.5	1.9	1.7	1.2
6. FIRE CONTROL COMPUTER	1.3	1.9	1.4	1.9
7. HUD ELECTRONICS	1.3	1.2	0.7	0.5
8. E/O DISPLAY ELECTRONICS	1.2	1.6	0.2	0.1
TOTAL	\$19.8	\$14.7	\$ 9.8	\$ 6.9

* RADAR COMPONENTS TO BE ADDED LATER

** WITH 25% "DEADSPOT" FOR MLSC



SUPPORTABILITY DEMONSTRATION TEST



- CONDUCTED DURING CCTS OPERATIONS
- 3500 FLYING HOURS
- NORMAL MAINTENANCE DATA COLLECTION
BUT BASE-LEVEL AUDIT
- CONTRACTOR RIGHTS FOR INSPECTION ON
HIGH BURNER COMPONENTS
- DEVELOPMENT OF VERIFICATION TEST PLAN



LOGISTICS SUPPORTABILITY DEMONSTRATION



- SYSTEM LEVEL SUPPORTABILITY
 - IF MEASURED LESS THAN TARGET, AWARD FEE OF UP TO \$6.4 MILLION
- "HIGHBURNER ITEM" SUPPORTABILITY
 - IF MEASURED LESS THAN TARGET, AWARD FEE OF UP TO \$2.0 MILLION
 - IF MEASURED OVER 25% ABOVE TARGET, CORRECTION OF DEFICIENCIES REQUIRED
 - ENGINEERING CHANGES AND MOD KITS
 - ADDITIONAL ASSETS



RELIABILITY IMPROVEMENT WARRANTY

- BASIC OPTION
 - FIRM FIXED PRICE
 - SELECTED NOT LATER THAN LONG LEAD ITEM RELEASE
 - CONTRACTOR DEPOT REPAIR
 - 300,000 FLYING HOURS OR FOUR YEARS
- MTBF GUARANTEE
 - FIRM FIXED PRICE
 - RIDER TO BASIC OPTION
 - CONTRACTOR LOANS ADDITIONAL SPARES IF MTBF NOT MET
 - INCENTIVE FOR CORRECTION

MTBF

COMPONENT •	UNIT MTBF (HOURS)		
	1-12 MONTHS	13-24 MONTHS	25-36 MONTHS
1. INERTIAL NAVIGATION UNIT	185	284	300
2. FLIGHT CONTROL COMPUTER	162	242	260
3. RADAR E/O DISPLAY	155	228	244
4. HUD DISPLAY	170	212	224
5. DIGITAL SCAN CONVERTER	210	330	350
6. FIRE CONTROL COMPUTER	415	600	640
7. HUD ELECTRONICS	325	470	500
8. E/O DISPLAY ELECTRONICS	155	228	244

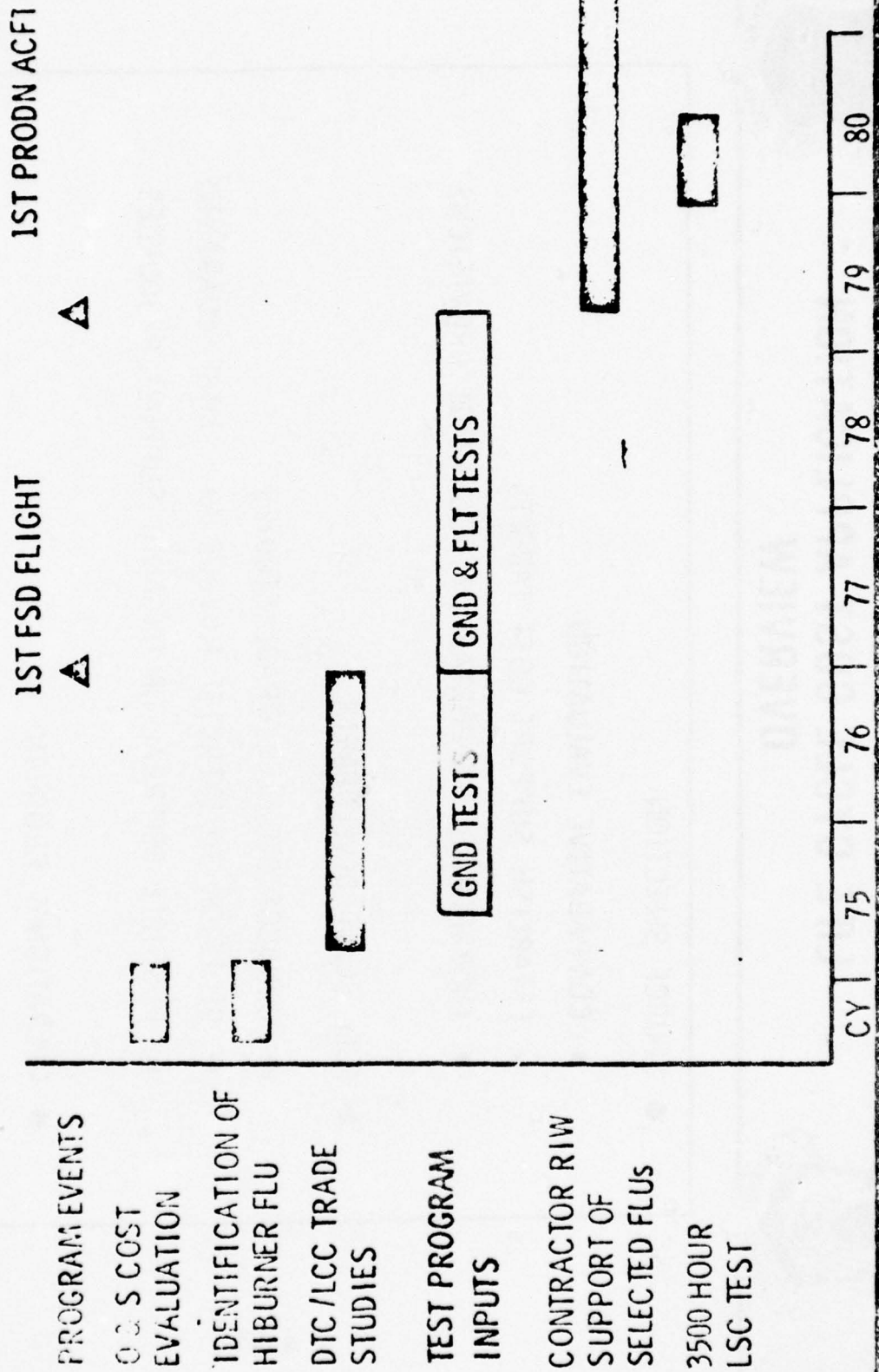
• RADAR COMPONENTS TO BE ADDED LATER



LIFE CYCLE COST APPLICATION OVERVIEW

- SOURCE SELECTION
 - COMPARATIVE EVALUATION
 - ESTABLISH SUPPORT COST TARGETS
 - INCORPORATE SUPPORTABILITY CONTRACT PROVISIONS
- FULL SCALE DEVELOPMENT
 - CONDUCT DTC / LCC TRADE STUDIES
 - DECISION TO EXERCISE RIW OR RIW / MTBF GUARANTEE
 - POSSIBLE DEFERRAL OF ORGANIC SUPPORT RESOURCES
- OPERATIONAL PROGRAM
 - CONDUCT DEMONSTRATION TEST
 - DETERMINE AWARD FEES
 - INITIATE CORRECTION OF DEFICIENCIES

LIFE CYCLE COST APPLICATION





PROBLEMS IN APPLICATION

- EVALUATING ESTIMATES DURING SOURCE SELECTION
 - ASSURING COMPARABILITY
 - DETERMINING REASONABLENESS
- CONTRACTORS DID NOT BELIEVE GOVERNMENT SERIOUS
 - LONG TERM COMMITMENT UNREASONABLE
 - CONFLICTING POLICIES - CIP
 - DEVELOPMENT UNCERTAINTY - RADAR
- POTENTIAL LEGAL ENFORCEABILITY
- LACK OF EXPERTISE IN LCC PROCUREMENT AREA

SUMMARY

- WE HAVE A VIABLE PROGRAM FOR REDUCING LCC
 - INCENTIVIZED TRADE STUDIES - DTC AND LCC
 - DTC GOAL VS LCC SAVINGS
 - LOGISTICS SUPPORTABILITY COST COMMITMENTS ON CONTROL FLUS
 - INCENTIVE FOR SUPPORT COST REDUCTIONS ON SYSTEM AND OTHER FLUS
 - LOGISTIC SUPPORT ANALYSIS
 - IN-HOUSE STUDIES AND SIMULATIONS
 - SUPPORTABILITY IMPACT OF ECPS
- OUR WORK IS JUST BEGINNING

AVIONICS PROLIFERATION
A LIFE CYCLE COST PERSPECTIVE

30 July 1975

by

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The development, production and fielding of an uneconomically large number of different avionics subsystems performing the same basic function is known as "proliferation." Proliferation results in greater expenditures in research, development, production, and logistic support. Furthermore, limited funds may be spread too thin to sufficiently concentrate research to develop low cost, reliable avionics. Likewise, sufficient product improvement funds may not be available to effectively "mature" the reliability of a multitude of functionally similar avionics subsystems, or to make logistic support improvements such as refinement of depot repair processes for lower cost per repair.

The question addressed in this article is, *"For a given level of performance, when does adding a new item of avionics to the inventory constitute wasteful proliferation, and conversely, when does it constitute an economy?"*

We obviously cannot afford to develop a complete new set of avionics subsystems for every new aircraft, nor, on the other hand, should we insist that all aircraft use the same basic set of avionics subsystems. Consider the case of aircraft inertial navigation subsystems. Bombers

We wish to express our appreciation to Russell R. Shorey, Director, Acquisition and Support Planning, Office of the Assistant Secretary of Defense, Installation and Logistics, for his help in the formulation of the paper, model development, and review of the draft versions. We also wish to thank the members of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems for their many ideas which we freely borrowed and incorporated in our model.

and reconnaissance aircraft generally require highly accurate inertial navigation subsystems which are more expensive than the medium accuracy subsystems needed for fighter, cargo, and tanker aircraft. It would be uneconomical to require that all fighter, cargo, and tanker aircraft use the more precise and expensive inertial navigation subsystems. Within the family of medium accuracy inertial system users there is, however, a legitimate issue of whether or not we should insist on a greater degree of inertial navigation standardization as new aircraft are added to the inventory.

In examining the issue of proliferation we must consider that advances in the state-of-the-art may produce subsystems that are more reliable and less costly to acquire and maintain. On the other hand, if this consideration were taken to the extreme, every new aircraft of these types would have a different inertial navigation subsystem, since at any point in time there is bound to be an "improved" version, with a claim of projected savings. The basic economic issue is that of subsystem life cycle costs across multiple aircraft applications. This will be illustrated with contemporary inertial navigation hardware. Figure 1 summarizes three aircraft inertial navigation subsystems used in our analysis. We did not of course, use data on specific contractor's actual hardware, but we did take care to accurately portray three classes of hardware.

The first of the three represents the best of inertial navigation subsystems developed for the military presently in the inventory. The second represents inertial navigation subsystems developed by private

FIGURE 1: INERTIAL NAVIGATION SYSTEMS

TYPE SYSTEM	CURRENT STATUS	PLATFORM	
		PRODUCTION COST (EACH)	PLATFORM RELIABILITY
PAST MILITARY DEVELOPMENT	IN DOD INVENTORY	\$77,000	300 HOURS
DEVELOPED COMMERCIALLY FOR THE AIRLINES	USED BY AIRLINES NOT IN DOD INVENTORY	\$92,000	900 HOURS
PROPOSED MILITARY DEVELOPMENT	FEASIBLE BUT REQUIRES DEVELOPMENT	\$39,000	1500 HOURS

industry for the commercial airline market, and is typical of those currently used by several airlines. This subsystem is not presently in the military inventory, however. The third is typical of proposed new developments for the military that are based on major breakthrough affecting producibility, reliability, and to a lesser extent, maintainability.

A detailed, computerized accounting-type life cycle cost model was developed by the authors to make the cost estimates presented in this paper. Careful attention was paid to accurate representation of all start-up costs, and realistic field and depot overhead costs. Furthermore, the model was constructed so that it could be exercised without distortion over a large range of aircraft fleet sizes and equipment reliabilities.

In considering proliferation, we are particularly interested in what "extra" costs have to be considered when a new item is introduced into the inventory. We have called them "start-up" costs and define them as: "The research, development, test and evaluation (RDT&E) and initial logistic support costs peculiar to introducing a new item into the inventory. Furthermore, they are NOT dependent upon the number of aircraft." The "start-up costs," for the three inertial navigation subsystems of our example are shown in Figure 2.

RDT&E costs are zero for the existing military and the commercial airline systems as the former is in the inventory already and the latter is "off-the-shelf." However, the new development is charged \$20,000,000. At the depot, a basic set of test equipment already exists for the subsystem already in the inventory. For a large number of new aircraft

FIGURE 2: "START-UP" COSTS

(All costs in millions of dollars)

<u>Cost Category</u>	<u>INERTIAL NAVIGATION SYSTEM</u>		
	<u>Existing Military</u>	<u>Commercial Airline</u>	<u>New Development</u>
RDTGE	0	0	20.0
DEPOT			
Test Equipment	0	3.2	1.2
Facilities	0	1.0	0.4
Airborne Equipment Tech Data	0	0.5	1.0
Test Equipment Tech Data	0	0.7	0.5
Test Equipment Software	0	0.5	0.5
Spares	0	0.4	0.2
Training	0	0.3	0.3
FIELD			
Data	0	0.5	0.5
Initial Training	0	0.5	0.5
LOGISTICS MANAGEMENT	<u>0</u>	<u>0.2</u>	<u>0.2</u>
TOTAL START- P COST	0	7.8	25.3

some duplicative specific test equipment items will have to be added to the already existing basic equipment set to handle added workload. However, in the limit as the number of new aircraft approaches zero, no new test equipment is required, hence the zero value for the existing subsystem. In the case of the commercial INS and new development however, a basic or minimal set of test equipment would be required to support even one aircraft, hence the costs shown in Table 2. Here also, as the number of new aircraft is increased, some additional, duplicate items of test equipment would have to be added to handle the increased workload at the depot but this is unrelated to "start-up." The same reasoning used in depot test equipment applies to depot facilities. Depot start-up costs related to tech data, software, and initial training are not required for subsystems already in the inventory, however, they are required if the subsystem is in the inventory. Depot spares are more subtle, however. As the depot workload approaches zero, the spares required at the depot do not approach zero but instead approach the "minimum depot line load." The minimum depot line load has already been purchased for a subsystem already in the inventory but it is a start-up cost if the subsystem is not in the inventory. Field data and training start-up costs are not required for subsystems in the inventory. Finally, there are some special start-up costs for logistics management on subsystems not in the inventory.

Shown in Figure 3 are the total 10-year life cycle costs per inertial navigation system on one or more new fighter aircraft, versus the total number of new aircraft. From Figure 3 it can be seen that for the installation of inertial navigation systems in new aircraft type or

types, proliferation has occurred if a subsystem not already in the inventory is used below about 200 aircraft. While proliferation will not have occurred if more than 200 aircraft are involved, and the reliability, production cost, etc., represent a sufficient advance over the best of the existing subsystems in the inventory to cause the cross-overs illustrated in Figure 3. When the number of aircraft exceeds several hundred, then low production costs, high reliability, and low cost per repair can offset large initial costs in the realm of \$15-25 million.

In the past, we may have introduced too many new items of avionics that did not represent sufficient advances in the state-of-the-art from a life cycle cost viewpoint. This may have incurred needlessly high costs in engineering development and logistics start up. When we did buy a "lemon" we have sometimes spent insufficient funds to bring it up to acceptable degrees of reliability and economic repair. Certainly we have profitably invested sizeable resources in basic research to improve performance state-of-the-art, but perhaps we have spent too little on basic research to improve the life cycle cost state-of-the-art, i.e., technological improvements in producibility, reliability, maintainability, and logistic support refinements after initial fielding.

In our haste to do better, however, we must not mistake the symptoms for the problem itself. Symptomatic related solutions might include elimination of proliferation through "legislation" of standard subsystems, much larger "across-the-board" investments in basic research related to producibility, reliability, and maintainability, and "curing"

LIFE CYCLE COST PER AIRCRAFT

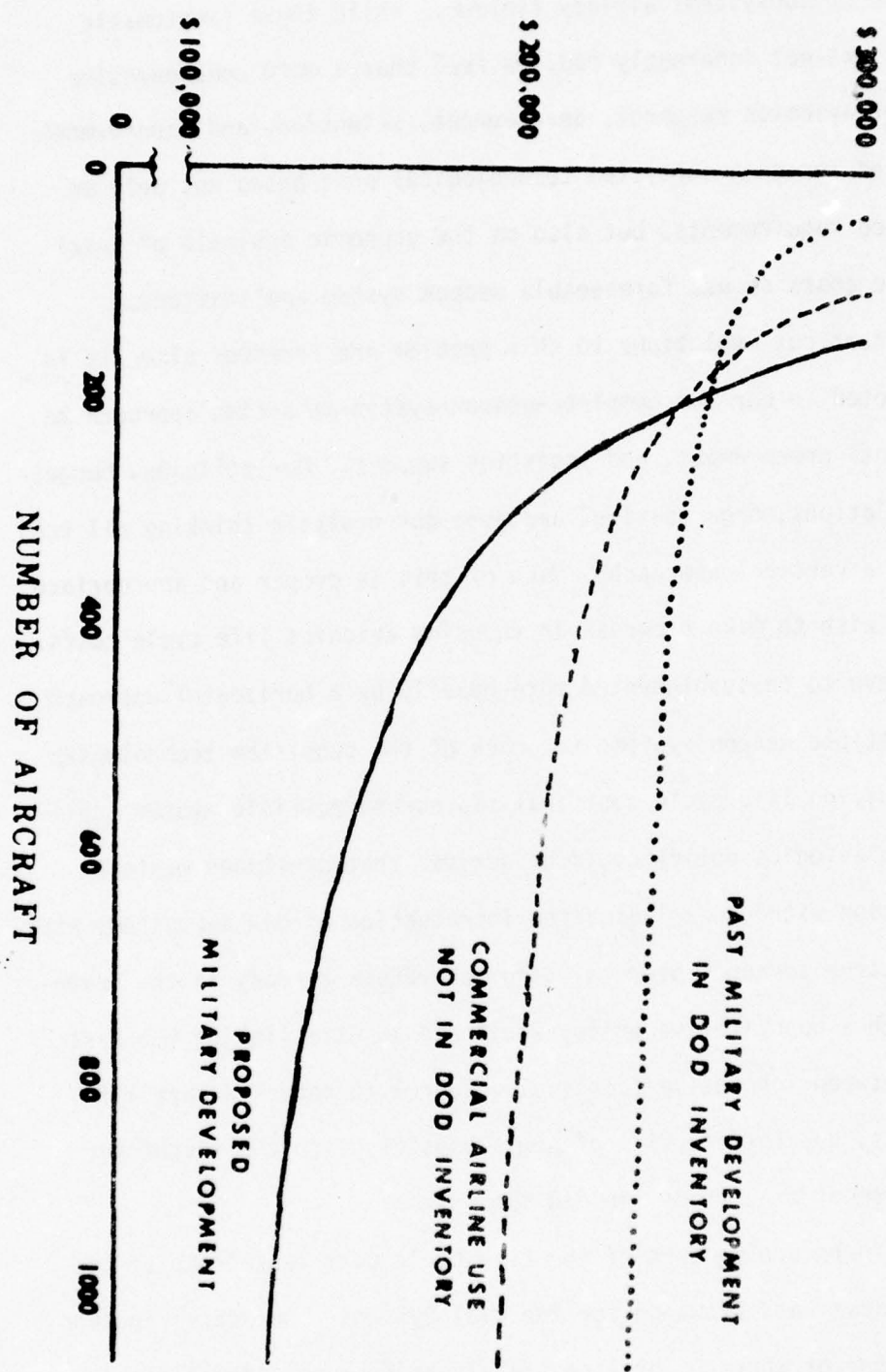


FIGURE 3: COST CURVES

all the lemon subsystems already fielded. While these symptomatic solutions are not inherently bad, we feel that a more comprehensive program of avionics research, development, selection, and improvement is required for *each* subsystem technological area based not only on performance requirements, but also on the economic analysis of total life cycle costs on *all* foreseeable weapon system applications.

No "short cut" solutions to this problem are foreseen since it is deeply rooted in our one-complete-weapon-system-at-a-time approach to development, procurement, and logistics support. Our policies, budgeting, regulations, organization, and even our analytic thinking all tend to assume a vertical approach. Much of this is proper and appropriate, but if we wish to make progress in reducing avionics life cycle costs, it will have to be supplemented more heavily by a horizontal approach across multiple weapon systems for *each* of the subsystem technologies.

By applying life cycle cost analysis across multiple system applications an avionics policy could be derived that precludes wasteful proliferation without excluding the introduction of new subsystems that represent true advances over existing subsystems already in the inventory. Such a quantitative policy would aid in establishing the best balance between innovative technical research to reduce future life cycle costs, the introduction of new subsystems into the inventory, and improvement of already fielded subsystems.

The authors are members of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems. Our participation, in this group of working level cost analysts from key agencies and

industries in the inertial navigation technological specialty, has convinced us that the requisite analytic tools are at hand. A similar life cycle cost task group in the area of jet engine technology has been formed and has similar goals. Thus, it appears that the necessary cooperative government and industry groundwork is starting to be laid, *technology at a time*, to understand the economies of proliferation from the perspective of subsystem life cycle costs across multiple system application.

APPENDIX A: BIBLIOGRAPHY

1. Robert E. Adel, William J. Boner, Keith J. Gibson, Three Life Cycle Cost Models for Inertial Systems.

The purpose of this report was to present three different life cycle cost models for inertial systems to the membership of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems for the purpose of familiarization prior to the April 1974 meeting of that group in Anaheim California. The report includes three life cycle cost models that have been used in economic analysis of inertial navigation systems.

2. Russell M. Genet, Generalized Conclusions Concerning Life Cycle Costs of Air Force Inertial Navigation Systems.

An analysis was made of Air Force inertial navigation systems. The major factors influencing the cost of these systems were determined. It was concluded that the development of inertial systems that could be cheaply produced was the most pressing problem. The paper was based on previous analysis by Mr Genet, and it contains a bibliography of key papers in the area of life cycle costs of inertial navigation systems. AD 909665 LD 28983

3. _____, Results of a Logistical Analysis of the Depot Level Repair of Air Force Inertial Guidance Systems.

A discussion of the influence of test errors and reassembly errors on the depot repair of complex equipment (inertial navigation systems are used as an example). This essentially nonquantitative report summarizes previous detailed studies. It was found that diagnostic and functional test errors were very costly, and that this avoidable cost went largely unrecognized since it is not directly observable. AD 909488

4. _____, An Unbiased Indicator of Depot Repaired Equipment Reliability (With an LN-12 IMU Example).

A method for determining equipment reliability trends based on data readily available at a repair depot was developed by Mr Genet. The method was applied to LN-12 inertial measurement units manufactured by Litton Industries and repaired at the Air Force's Aerospace Guidance and Metrology Center in Newark, Ohio. It was found that the mean operating time between depot level repairs remained remarkably constant for the previous 5 years. AD 909621 LD 28985

5. _____, Future Logistics Management and Complex Equipment Item Tests.

This paper suggests why the coordination and improvement of

equipment tests were not a serious problem for logistics managers until the equipment became highly complex. The paper discusses the large magnitude of support cost increases that can occur if logistic management techniques are not brought to bear on this problem area associated with complex items. The paper concludes with a brief survey of the new logistics test management techniques, many of which have been borrowed from psychology and medicine, that can be focused on this problem. AD 909625 LD 29305

6. _____, Procurement and Maintenance of Inertial Instruments and Systems in the Royal Swedish Air Force.

Sweden a relatively small country with a small but modern air force has developed unique but highly effective approaches to the procurement and support of complex subsystems. This report discusses their approach to the procurement and maintenance of inertial instruments and systems. They place considerable emphasis on determining the cost of an item over its entire life prior to any large scale procurement. The report was based on a trip to Sweden by Mr Russell M. Genet of the US Air Force, Aerospace Guidance and Metrology Center, at Newark Air Force Station, Newark, Ohio. AD 909626 LD 28986

7. _____, On Dogs or How to Determine When it is Uneconomical to Continue Repair.

Several papers have been written by personnel at RAND, Hq AFLC, Logistics Management Institute, AFIT, etc., on the general question of whether it is better, economically, to repair an item to begin with, or to throw it away (or cannibalize it for parts). Most of these papers have not, however, addressed the question of once repair has been started, when does it become uneconomical to continue the repair? It is the objective of this paper to show how to determine when it is uneconomical to continue repair, and to illustrate this with an actual example. AD 909491

8. _____, The Future Role of Man in the Repair of Navigation Systems.

Human factors involved in the repair of navigation systems are discussed. The human factors in fault diagnosis, repair action decisions, making repairs, and performance evaluation after repair is discussed. The paper was presented by the author at the Institute of Navigation's 25th Anniversary Symposium at the US Air Force Academy in Colorado in 1971.

9. _____, Avionics Cost Reduction Through Improved Tests.

Although cost has always been a consideration in the selection and use of tests for the repair of avionics, the present widespread use of very expensive avionics has necessitated refinements in testing with the goal of reducing repair costs. The relationship between

testing and repair costs is rather complex, and only recently has it come under close scrutiny. It is the purpose of this paper to examine the recent analytic work relating avionics testing to repair costs. This paper covers the most important aspects of this body of research on the relationship between avionics testing and repair costs with the hope that the reader will be able to apply this research to reducing the cost of repairing his own avionics. A summary and list of references is provided at the end of this paper. AD 787188

10. Russell M. Genet, Cynthia Erwin and Donald L. Hardy, Jr. A Life Cycle Cost Analysis of a Standard Medium Accuracy Inertial Navigation System for Multiple Aircraft Applications.

This study determined how much money could be saved by the Air Force if it developed or adopted an existing item as the standard system for all aircraft requiring an inertial navigation system of medium accuracy. The study was done on a parametric basis with production cost per unit and reliability the main parameter varied. The study concluded that while several existing systems might be attractive as candidates for a "standard system" that if it were possible to develop a system that could be produced for \$40,000 each with a reliability of 500 hours (MTBF) that it would be much more attractive. AD 909628 LD 28987

11. Russell M. Genet and R. Patrick Handley, Auditing the Quality of Test Decisions and Test Equipment at AGMC.

It has been found that test decisions made in some repair processes can critically affect the efficiency of the process and the quality of the product. A program for auditing the quality of test decisions at the Aerospace Guidance and Metrology Center (AGMC) is suggested. This program is meant to check both the repeatability as well as the validity of both diagnostic and functional test decisions. AD 918392

12. _____, Rebuild vs Repair: A Logistics Analysis.

This paper examines the economic, and other pertinent logistic factors of a maintenance concept that "always rebuilds units completely" (ARUC), versus one that "diagnoses and repairs as necessary" (UARAN). The examination of these two maintenance approaches is made by constructing a mathematical cost model, and then exercising this model under a large number of widely varying conditions. AD 909532

13. Russell M. Genet and Donald L. Hardy, Jr., Life Cycle Cost Analysis of Inertial Systems for Aircraft and Air to Surface Missiles.

The life cycle costs of 14 inertial systems were examined as applied to the B-1 bomber. The life cycle costs varied from under \$100 million to over \$300 million dollars. This report discusses the

overall cost analysis problem, describes the cost model used in the evaluation, lists the data inputs and analysis outputs, draws overall conclusions and examines the sensitivity of these conclusions to variations in the input data. Numerous appendices give detailed results. AD 909619

14. Russell M. Genet and Don Hunt, Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems Jan 74.

These proceedings describe the first meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems. The report contains copies of educational presentations on various subjects connected with life cycle costing and with maintenance warranties. AD 785391

15. Russell M. Genet, Richard Martin, and Roosevelt Besteda, An Economic Analysis of G-200 Bearing Replacement Policies.

At the request of the Air Force Chief of Staff (General Ryan) a project was initiated to improve the F-4 avionics, particularly the LN-12 inertial navigation system. As a part of this project a new bearing was designed for the G-200 gyroscope, a key instrument in the LN-12. This report examines the economic reliability impact of introducing the new bearing at different rates. Since the actual reliability of the new bearing was unknown, the analysis was done parametrically with this reliability as the parameter. AD 909630
LD 28983

16. Russell M. Genet, Phillip Ruud, Lt James Haugen, and C. B. Santos, A Short Run Economies of Scale Analysis of the Aerospace Guidance and Metrology Center (AGMC).

A simplified methodology for evaluating the short run economies of scale of a repair depot is given. An illustrative example applying to methodology to the Aerospace Guidance and Metrology Center, the Air Force's repair depot for inertial systems for missile and aircraft is given. Very approximate data is used and is for purpose of illustration only. AD 922397

17. Russell M. Genet, et al, An Economic Model of a Repair Depot.

The development, capabilities, and structure of an economic model of a military repair depot are described. Background on the objectives of a military repair depot and planning and analysis requirements for such depots is given. The model is described in terms of inputs, outputs and functional relationships between variables. The capabilities of the model to do various planning and analysis tasks are described. Conclusions and recommendations for further work are given and a bibliography is appended. An appendix volume contains sample runs and backup data for a case example (AGMC). identical model equations and program listings. AD A003476

18. Don E. Hunt, A Model for Contract Pricing for use by Government Depots in Conjunction with the use of Government Depot Warranties in Multi-Year Contracting at Fixed Prices.

This paper examines the fundamental economic considerations of the maintenance warranty concept, embodied in fixed pricing and multi-year contracting. A model is developed which provided a satisfactory incorporation of these concepts into a government depot maintenance warranty. The model provides a framework within which the government maintenance depot may acquire a limited profit or may incur a loss dependent solely upon the capabilities and efforts of the depot. AD 921656L LD 32079A

19. Don Hunt, Russell M. Genet, and Theodore E. Crosier, Government Depot Maintenance Warranties.

This paper was presented to the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems 19 Aug 74, for review and comment. It is a thought provoking attempt to introduce the concept of government depot maintenance contracting technique. The paper examines the advantages and disadvantages to be expected from such a concept and briefly describes what a depot maintenance improvement warranty might consist of and how it might work. AD 922375L

20. Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems, Proceedings of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems.

These proceedings describe the 4th quarterly meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems. This meeting was held 19 Aug 74 in Cambridge, MA. The conference proceedings include a foreword by the Task Group Chairman, Russell B. Stauffer, educational presentations by Task Group members, and the proceedings of the newly formed Executive Board including plans for the 1974-75 year. AD 787220

21. Thomas Meitzler, Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems, Proceedings, Apr 74.

These proceedings describe the second quarterly meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems. The report includes an introduction by Task Group Chairman, Russell Genet, and educational presentations on life cycle costing. Also included is a report on progress towards a "standardized" government/contractor life cycle cost model for inertial systems. AD 785390 LD 31985AB

22. _____, Proceedings of the June 1974 Meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems.

These proceedings describe the third quarterly meeting of the Life Cycle Cost Task Group of the Joint Services Data Exchange for Inertial Systems. This meeting was held 11-13 June 1974, in Kennebunkport, Maine. The conference proceedings include an introduction by the Task Group Chairman, Russell M. Genet, educational presentations by several task group members, and summaries of three working groups. These three groups derived first-cut algorithms for the improved life cycle cost model in the areas of" (1) research, development, test and evaluation; (2) Acquisition; (3) operation and maintenance. AD 787195

23. Thomas D. Meitzler and Russell M. Genet, A Description of a Life Cycle Cost Model for Inertial Navigation Systems.

The purpose of this report is to document a mathematical model that has been used to evaluate the potential life cycle costs of inertial navigation systems. The model has been previously published; however, because of sensitive data, it had a limited distribution. This report includes definitions of all input and output parameters, explanations of algorithms for the model, a sample run using fictitious data and a program listing which includes a sensitivity study. AD 785392

24. Aibert R. Neville, Jr., Colonel USAF, and Russell M. Genet. Testing the Tests or the Quality of Diagnostic and Functional Tests Used in the Repair of Inertial Systems at the Aerospace Guidance and Metrology Center.

This paper discusses the evaluation and improvement of tests used during the repair of inertial navigation systems at the Aerospace Guidance and Metrology Center (AGMC) at Newark Air Force Station, in Newark, Ohio. The highly significant impact of both diagnostic and functional test errors on the efficiency of the overall repair process is discussed. An evaluation program at AGMC to "test the tests" is described. The results should be generally applicable to any repair process that uses diagnostic tests combined with selective replacement. LD 31987A

APPENDIX B. MODEL INPUT/OUTPUT USED IN ANALYSIS

This appendix contains copies of the basic computer printout of the input data and output results used for this report. Normally these two sets of data appear on one sheet; however, for reproduction in this report, it was necessary to use two pages.

(For pages 3-169 to 3-178, Basic Computer Printout, order AD A016478.)

APPENDIX A

MINUTES OF THE EXECUTIVE BOARD
MEETING
OF THE LCC TASK GROUP

31 July 1975

APPENDIX A

MINUTES OF THE EXECUTIVE BOARD MEETING OF THE LCC TASK GROUP 31 July 1975

The Executive Board of the LCC Task Group including newly elected members Mrs. Frieda Kurtz and Mr. James Taylor met on Thursday, July 31st, 1975. Mr. Stauffer and Mr. Palmer were asked to continue to serve as chairman and vice-chairman, respectively. Principle discussion at the meeting was centered around the task to be accomplished between that date and the end of the year. It was agreed that in addition to the coding of the model which is being accomplished by Keith Gibson it would be necessary to have a User's Guide. Mr. Stauffer accepted the action item to prepare a detailed outline of that guide and suggested the following writing assignments.

1. The RDT&E section of the guide would be prepared by Mr. Stauffer, the Acquisition section would be prepared by Mr. Robert Adel, the Input section by Don DeBurkarte, the General Description of the Model by Keith Gibson and the Output section by Bill Colcord. It was also decided that a mid-September meeting to discuss progress and review what has been accomplished on the User's Guide and the model should be held in mid-September*, probably in the

Los Angeles area. Bob Adel was requested to make the Life Cycle Cost presentation which had been previously prepared at the Joint Services Data Exchange meeting in November.

A detailed set of minutes of that meeting has been distributed to a limited number of active personnel within the Life Cycle Cost Task Group. (Other readers who would like to have the details are invited to write to the chairman for them.)

NOTE: As of the writing of these proceedings, the September meeting has in fact been held. In addition to the acceptance of the assignments and good progress on the User's Guide, it was determined that the pressure of regular activities had prevented Keith Gibson from proceeding as far with the programming as he had hoped to be able to proceed. He did state however, that he was preparing specifications so that we could take advantage of Mrs. Kurtz's agreement to provide programming assistance at the Air Force Avionics Lab provided that specifications which require none of her personal time could be provided.

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APPENDIX B

SYMBOLS AND DEFINITIONS USED

IN

LIFE CYCLE COSTING

Provided by

Peter J. Palmer

Charles Stark Draper Laboratory
Cambridge, Massachusetts

Symbols and Definitions Used
In Life-Cycle Costing

ABLE	=	<u>A</u> cquisition <u>B</u> ased on <u>C</u> onsideration of <u>L</u> ogistics <u>E</u> ffects
A/C	=	<u>A</u> ircraft
ADC	=	<u>A</u> ir <u>D</u> ata <u>C</u> omputer
ADI	=	<u>A</u> ttitude <u>D</u> irection <u>I</u> ndicator
ADPA	=	<u>A</u> merican <u>D</u> efense <u>P</u> reparedness <u>A</u> ssociation
AFAL	=	<u>A</u> ir <u>F</u> orce <u>A</u> vionics <u>L</u> aboratory
AFHRL	=	<u>A</u> ir <u>F</u> orce <u>H</u> uman <u>R</u> esources <u>L</u> aboratory
AFLC	=	<u>A</u> ir <u>F</u> orce <u>L</u> ogistics <u>C</u> ommand
AFSC	=	<u>A</u> ir <u>F</u> orce <u>S</u> ystems <u>C</u> ommand
AGARD	=	<u>A</u> dvisory <u>G</u> roup for <u>A</u> erospace <u>R</u> esearch and <u>D</u> evelopment of NATO
AGE	=	<u>A</u> erospace <u>G</u> round <u>E</u> quipment
AGMC	=	<u>A</u> erospace <u>G</u> uidance and <u>M</u> etrology <u>C</u> enter
AIAA	=	<u>A</u> merican <u>I</u> nstitute of <u>A</u> eronautics and <u>A</u> stronautics
AOA	=	<u>A</u> ngle <u>O</u> f <u>A</u> ttack
ARP	=	<u>A</u> rmament <u>R</u> elease <u>P</u> anel
ASCU	=	<u>A</u> rmament <u>S</u> tation <u>C</u> ontrol <u>U</u> nit
ASD	=	<u>A</u> eronautical <u>S</u> ystems <u>D</u> ivision
ASME	=	<u>A</u> merican <u>S</u> ociety of <u>M</u> echanical <u>E</u> ngineers
ASO	=	<u>A</u> viation <u>S</u> upply <u>A</u> gency
ATE	=	<u>A</u> utomatic <u>T</u> est <u>E</u> quipment
AWACS	=	<u>A</u> irborne <u>W</u> arning and <u>C</u> ontrol <u>S</u> ystem
AWM	=	<u>A</u> waiting <u>M</u> aterial
BITE	=	<u>B</u> uilt-In <u>T</u> est <u>E</u> quipment
CEP	=	<u>C</u> ircular <u>E</u> rror of <u>P</u> robability
CER	=	<u>C</u> ost <u>E</u> stimating <u>R</u> elationship
CFP/TDP	=	<u>C</u> oncept <u>F</u> ormulation <u>P</u> ackage/ <u>T</u> echnical <u>D</u> evelopment <u>P</u> lan
CLAMP	=	<u>C</u> losed <u>L</u> oop <u>A</u> utomatic <u>M</u> anagement <u>P</u> rogram
CO	=	<u>C</u> ost of <u>O</u> wnership
C/SPEC	=	<u>C</u> ost/ <u>S</u> chedule <u>C</u> ontrol <u>S</u> pecification

CONUS = Continental United States
DAIS = Digital Avionics Integrating System
DC or D/C = Design to Cost
DCASR = Defense Contract Admistrative Services Region
DCC = Design to Cost Council
DCP = Development Concept Paper
DCS = Deputy Chief of Staff
DOD = Department of Defense
DODT = Design Option Decision Trees
DRS = Doppler Radar Set
DSA = Defense Supply Agency
DSARC = Defense System Acquisition Revue Council
DTC = Deisgn to Cost
ECP = Engineering Change Proposal
ESD = Electronics Systems Division
FAT = Factory Acceptance Test
FFW = Failure Free Warranty
FLR = Forward Looking Radar
GFE = Government Furnished Equipment
HSI = Horizon Situation Indicator
HUD = Heads-Up Display
IEEE = Institute of Electrical and Electronic Engineer
IILSAC = Industry Integrated Logistic Support Advisory Committee
ILS = Integrated Logistic Support
IMA = Intermediate Maintenance Activity
IMS = Intertial Measurement Set
IMU = Intertial Measurement Unit
IPM = Incentive Performance Measurement
IROS = Increased Reliability for Operational System
IT&E = Initial Test and Evaluation
JSDE/IS = Joint Services Data Exchange for Intertial Systems

LCC = Life Cycle Cost
LCCTG = Life Cycle Cost Task Group
LOR = Level of Repair
LRU = Line Replaceable Unit
LSA = Logistic Support Analysis
LSC = Logistics Support Costs
MAF = Maintenance Action Form
MFS = Master Function Switches
MFTBMA = Mean Flying Time Between Maintenance Actions
MIS = Management Information System
MSP = Material Support Plan
MTBDR = Mean Time Between Depot Repair
MTBF = Mean Time Between Failure
MTBMA = Mean Time Between Maintenance Actions
MTBR = Mean Time Between Removals
MTBUR = Mean Time Between Unscheduled Removals
NAFS = Newark Air Force Station
NARF = Naval Air Rework Facility
NAS = Naval Air Station
NASA = National Aeronautics and Space Agency
NCMA = National Contract Management Association
NORM = Not Operationally Ready Due to Maintenance
NORS = Not Operationally Ready Due to Supply
NRTS = Not Repairable at This Station
NWDS = Navigation/Weapon-Delivery System
OAS = Office of the Assistant for Study Support
O&M = Operation and Maintenance
OPR = Office of Primary Responsibility
OR = Operationally Ready

ORLA	=	<u>O</u> ptimum <u>R</u> epair <u>L</u> evel <u>A</u> nalysis
ORS	=	<u>O</u> peration and <u>S</u> upport
OT&E	=	<u>O</u> perational <u>T</u> est and <u>E</u> valuation
PA&E	=	<u>P</u> rogram <u>A</u> nalysis and <u>E</u> valuation
PCR	=	<u>P</u> rogram <u>C</u> hange <u>R</u> equest
PIDA	=	<u>P</u> erformance <u>I</u> ncentive <u>D</u> ollar <u>A</u> ddjustment
PLT	=	<u>P</u> rocurement <u>L</u> ead <u>T</u> ime
PM	=	<u>P</u> reventive <u>M</u> aintenance
PMA	=	<u>P</u> rogram <u>M</u> anagement <u>A</u> ctivity
PMDS	=	<u>P</u> rojected <u>M</u> ap <u>D</u> isplay <u>S</u> et
PSPP	=	<u>P</u> roposed <u>S</u> ystem <u>P</u> ackage <u>P</u> lan
RAD	=	<u>R</u> equired <u>A</u> ction <u>D</u> irective
RCT	=	<u>R</u> epair <u>C</u> ycle <u>T</u> ime
RDT&E	=	<u>R</u> esearch, <u>D</u> evelopment, <u>T</u> est and <u>E</u> valuation
RFP	=	<u>R</u> equest <u>F</u> or <u>P</u> roposal
RFQ	=	<u>R</u> equest <u>F</u> or <u>Q</u> otation
RFR	=	<u>R</u> equest <u>F</u> or <u>R</u> esponse
RIW	=	<u>R</u> eliability <u>I</u> mprovement <u>W</u> arranty
R&M	=	<u>R</u> eliability and <u>M</u> aintainability
ROC	=	<u>R</u> equired <u>O</u> perational <u>C</u> apability
SAC	=	<u>S</u> trategic <u>A</u> ir <u>C</u> ommand
SAC	=	<u>S</u> ystem <u>A</u> cquisition <u>C</u> osts
SAMSO	=	<u>S</u> pace and <u>M</u> issile <u>S</u> ystems <u>O</u> rganization
SAVE	=	<u>S</u> ociety of <u>A</u> merican <u>V</u> alue <u>E</u> ngineers
SCAM	=	<u>S</u> ystems <u>S</u> upport <u>C</u> ost <u>A</u> nalysis <u>M</u> odel
SEAC	=	<u>S</u> upport <u>S</u> ystems <u>E</u> ffectiveness and <u>C</u> ost <u>M</u> odel
SMD	=	<u>S</u> ystem <u>M</u> anagement <u>D</u> irective
SME	=	<u>S</u> ociety of <u>M</u> ilitary <u>E</u> ngineers
SOLE	=	<u>S</u> ociety of <u>L</u> ogistics <u>E</u> ngineers

AD-A033 418

FAIRCHILD CAMERA AND INSTRUMENT CORP MOUNTAIN VIEW CA--ETC F/G 17/7
PROCEEDINGS OF THE LIFE CYCLE COST TASK GROUP OF THE JOINT SERV--ETC(U)
JUL 75 R B STAUFFER

UNCLASSIFIED

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SOW = S t a t e m e n t o f W o r k
SPD = S y s t e m P r o g r a m D i r e c t o r
SPO = S y s t e m P r o g r a m O f f i c e
SPP = S y s t e m P a c k a g e P l a n
SR = S c r a p R a t e
SRA = S p e c i a l R e p a i r A c t i v i t y
SRU = S h o p R e p l a c e a b l e U n i t
SSAC = S o u r c e S e l e c t i o n A c q u i s i t i o n C o u n c i l
SSEB = S o u r c e S e l e c t i o n E v a l u a t i o n B o a r d
TBO = T i m e B e t w e e n O v e r h a u l
TPM = T o t a l P r o g r a m M a n a g e m e n t
TPPC = T o t a l P a c k a g e P r o c u r e m e n t C o n c e p t
TRIPLE M =
3M = M a i n t e n a n c e a n c e M a t e r i a l M a n a g e m e n t
VE = V a l u e E n g i n e e r i n g i n e e r i n g
VECP = V a l u e E n g i n e e r i n g i n e e r i n g h e r e h o p o s a l

APPENDIX C

LIST OF ATTENDEES
LIFE CYCLE COST TASK GROUP MEETING
FAIRBORN, OHIO
July 29-31, 1978

Bob Beech	LTV/Vought Systems Div	Dallas, Texas	214-266-2394	Lead Engin
Keith Gibson	Autometrics Div, Rockwell Int	1268 Bering, Macaulay Court	714-528-9242	Logistics En
Peter J. Palmer	C.S. Draper Lab	PO Box 98 Virginia Road Concord, MA 01742	617-274-8250	Technical
Russell B. Stauffer	DYNAMICS RESEARCH Corp	60 Concord St WILMINGTON, MA 01887	617-658-400 x 312	MANAGER TIRAS
Dwight E. Collins	AFSC/AFLC LCC WouKing Group	ASD/ACL WPAPB Ohio 45433	513-255-6836/ 6847	Ops Res Analyst
ROBERT E. ADEL	NORTHROP ELECTRONICS	2301 W. 120 th St HAWTHORNE, CAL 90250	(213) 757-5181 Ext 2054	ILS SPEC
BRIAN W. KLATT	NORTHROP ELECTRONICS-PPD	100 MORSE ST. NORWOOD, MASS 02062	(617) 762-5300 x 740	CHIEF OF RECRUITING
JOHN W. KURTZ	AFRL/RL-113 LEICHT-PHILIPSON	60111-11111 AF 245F CHIEF 45433	617-513 255-7522 x 7529	Operations Personnel Manager

NAME	ORGANIZATION	ADDRESS	TELEPHONE	FUNCTION OR TITLE
CHARLES W. EDDY	Hq AFSC MAINE	WPAFB	513- 257-4210	LOGIST SPECIFIC
DON DEBURKARTE	COLLINS RADIO GROUP RI.	ENG. SPECIALTIES CEDAR RAPIDS TOWN 52406	319-395-5785	LIFE CY ANALYST
THOMAS McGUIRE	OFFICE OF Project Manager Navigation & Control Systems (OPNAVCON)	BUDG 2525 FT Monmouth NEW Jersey 07703	201 532-4476 4369	Operations Research Analyst
Earl Feder	Avionics Laboratory Fort Monmouth, NJ	AMSEL-VL-N Fort Monmouth, NJ 07703	201- 535-2623	ELECTRONIC ENGR
W. H. Colcord	LEAR SIEGLER, Inc. Instrument Div.	4141 EASTERN AVE SE. GRAND RAPIDS, MICH 49506	(616) 241-8444	LOGISTICS ANALYST
A. M. FRAGER	OASD/IT&L	PENTAGON	697-6882	LIFE CY COST ANALYST
Robert C. Coffin	AFIT/ENS	WPAFB	879-5344 2552549	AFIT STUD.

Russell Byse	AEROSPACE DIV HONEYWELL	13350 US Hwy 19 ST PETERS, FLA 33733 MS 406-4	813-531-4611 X120	ESG PROG SUPPORT
James W. Wilson	ASD/ACCX	WPafb, OH 45433	(513)-255-3588	Ops RECH
Anthony I Robinson	Rand Corp	1700 Main St Santa Monica Calif 90406	(213) 3930411	MRS
Samuel B CRAVES	AFIT	3043 ULAGA GREEN DARTMOUTH	426-9325	ADMIN
Richard A. Kowalski	ARINC Research Corp	2551 Riva Rd Annapolis, Md. 21401	(301) 268-9600	Group Manager
Oscar MARKOWITZ	AVIATION SUPPLY OFFICE U.S. NAVY	700 ROBBINS AVE PHILA., PA 19111	(215) 697-2861/2	SUPPLY ENGINE
Thomas Meitzler	Newark AFS	AGMC/XIRXE Newark, OH 43055	(614) 522-7501	MATHEMATICS

NAME	ORGANIZATION	ADDRESS	TELEPHONE	FUNCTION OR TIT
* John S. Gibson	ASD/ACL	Wright Patterson AFB Ohio 45433	513-2556836	Asst AFSC/AFSC Working 8.
* Perry C. Stewart	AFIC/AQM4	WPAFB, OH	513-257-2144	Ch, Leg A. DCS Acq C
* Jon F. Reynolds	AFIC/ACM4A	WPAFB, OH 45433	(513) 257-2141	Ops Records
* Alan D. Yaross	ASD/ACC	WPAFB, OH 45433	(513) 2554983	Chief, Adm sy
* Russell M. Genet	AFIC/ACWC/KEX	Newark AFS Newark Ohio 413055	(614) 140- 522 5493 CWC 614522 7501	Chief, Ind Engring
* Don H. Owen	AFIT/ENS	AFIT/ENS ROX 0057 WPAFB, OH	255-2579	STUDENT/A.